Lake Ontario Nearshore Water Quality Atlas

1976 – 79

Ontario
Ministry of the Environment
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Minister
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Deputy Minister

Lake Ontario Nearshore Water Quality Atlas

1976 – 79

Toronto, Ontario, 1980

Ministry of the Environment
Ontario

Water Resources Branch
Great Lakes Unit

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ISSN 0227-1028

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INTRODUCTION

The Province of Ontario has been engaged in Lake Ontario water quality surveillance since the beginning of this century. Earliest records are contained in reports dealing with investigations of potable water supplies carried out following the signing of the 1909 Boundary Water Treaty between Great Britain and the United States of America. Beginning in 1967, an extensive nearshore monitoring network was developed by the Province leading to establishment of a comprehensive Lake Ontario water quality surveillance program. This program was set up to evaluate the effectiveness of remedial and preventive measures and to assess the suitability of the nearshore for various water uses.

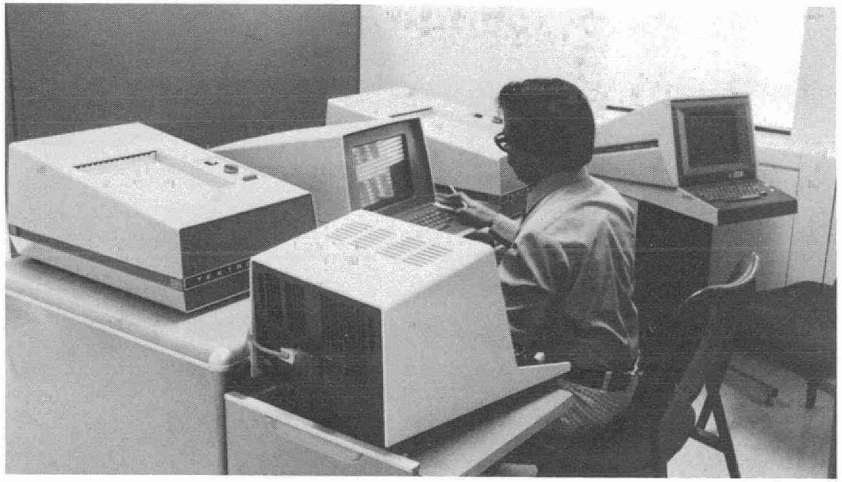
In the period 1967-1975, the nearshore monitoring network consisted of stations set out along a partial one-mile grid. Representative of studies carried out during this period is information collected in 1972 which subsequently was summarized in a publication entitled "Great Lakes Water Quality Data - 1972". In order to improve the areal resolution of nearshore water quality, the original sampling grid was modified in 1976 to a transect system which, following refinement, represents the present monitoring design.

The purpose of this publication is to present the most recent data which are indicative of the trophic state of the Canadian nearshore waters of Lake Ontario. Data summarized in this Atlas span the period from 1976 to 1979 and include information on regional and temporal (annual) differences in water quality based on spring conditions. Complementary programs addressing issues other than eutrophication such as trace contaminant distribution, bacteriological water quality degradation, and problem area assessment are dealt with in separate publications. Water quality and related data collected by the Ministry of the Environment in Lake Superior, Lake Huron, Georgian Bay, Lake Erie and in the interconnecting channels can be found in numerous other reports.

The present report should be of use to those who are interested in water quality conditions in Lake Ontario, to those who are concerned with regional nearshore developments and to those who may be undertaking studies in the area. We feel this Atlas not only provides a data base against which future changes in the nearshore can be assessed, but also serves as a useful tool for guiding future development planning along the Lake Ontario nearshore zone.

GUIDE TO ATLAS USE

To gain an insight into the water quality conditions observed in the Lake Ontario nearshore band for any reported year, or to better comprehend the temporal trends occuring in a nearshore region of interest, read a brief description on the subject presented in sections "Regional Water Quality" and "Temporal Water Quality", and study the corresponding coloured maps and graphics. If uncertain of scientific terminology or abbreviations, look up their significance or meaning under "Significance of Water Quality Variables", "Glossary" and "Symbols and Abbreviations".



Extensive computer facilities are used to handle a large data base generated by numerous surveillance programs.

The following guide is intended to aid in the interpretation of information presented in the coloured maps:

Zone	water mass which is significantly different from the remaining zones
N	number of stations within each of the zones
Mean	arithmetic mean of all stations within each zone based on an average of three replicates (runs) per station (geometric mean was used in the case of heterotrophic bacteria)
SD	standard deviation of above mean
Range	Maximum and minimum station means observed within each zone.

To obtain original numerical data for areas and years of specific interest, look up corresponding station numbers presented on the transect location maps and address your parameter request to:

Ministry of the Environment
Water Resources Branch
Planning & Co-ordination Section
Great Lakes Surveys Unit
135 St. Clair Avenue West
Toronto, Ontario, Canada
M4V 1P5

This information is stored on the SIS data base system and is only available on microfiche.

SURVEILLANCE DESIGN

Rationale

Water quality in the nearshore area of Lake Ontario is exceedingly difficult to monitor because of this zone's dynamic state. In the spring a thermal bar develops, limiting exchange between the nearshore (inside the thermal bar) and offshore (beyond the thermal bar) water masses. In early summer, thermal stratification sets in, effectively isolating the epilimnetic (top) from the hypolimnetic (bottom) waters. A strongly stratified situation, however, is rare in the near- shore band since upwellings and downwellings dominate the physical processes, thus exchanging vast water masses with nearly regular frequencies. Superimposed on the macroscale dynamics, are smaller fluctuations such as seiches, which further complicate the study of this zone.

In order to appreciate the variability in water quality one must also become familiar with the seasonal changes which take place in the lake. In the winter, isothermal conditions permit complete mixing of waters and regeneration of nutrients from sediments, with the result that in late winter, nutrient levels become elevated throughout the water column. In the spring, additional nutrients from spring runoff and rising water temperatures act to stimulate growth of diatoms. Spring chlorophyll concentrations depicted in this Atlas likely represent certain stages of the spring diatom pulse. However, since the onset, duration and intensity of the spring diatom pulse are highly variable from year to year, interpretation of chlorophyll _a_ data based on spring conditions should be done with caution. By late spring, algal blooms largely deplete the surface (epilimnetic) waters of nutrients, while dead algal cells sink downward into the water column where they release their nutrients (through microbial action) into the hypolimnetic waters. Nutrient depletion in the epilimnion continues during the summer, when green algae predominate and further remove phosphorus and nitrogen from the waters. In the fall, the lake cools and strong winds tend to break down the remaining stratification with the result that, by early winter, the nutrient-rich hypolimnetic waters are once again mixed with the rest of the lake.

The Ministry of the Environment has developed a strategy for monitoring the nearshore areas of Lake Ontario with an aim to assessing both spatial and temporal (annual) differences while taking into account the physical processes governing this active region.

By restricting its synoptic nearshore surveillance activities to the spring period, the Ministry optimizes its monitoring effort by taking advantage of vertical homogeneity prevailing in the water column at that time, and consequently being able to restrict sampling to surface waters only. Spring sampling has the added advantage of permitting an increased resolution of nearshore regional differences in water quality since the thermal bar accentuates the effects of shore inputs by restricting their complete mixing with the open lake. Furthermore, data collected in the spring are subjected to less temporal variability than those collected in the summer months when the physical processes, such as upwellings, acting upon the nearshore region are far more disruptive to its integrity.

Station Locations

The evolution of the nearshore transect design can be followed over the 1976-1979 period by examining station location maps. Although during this time transect locations have shifted somewhat to better resolve regional differences - and inshore-offshore gradients, the basic concept has remained unchanged.

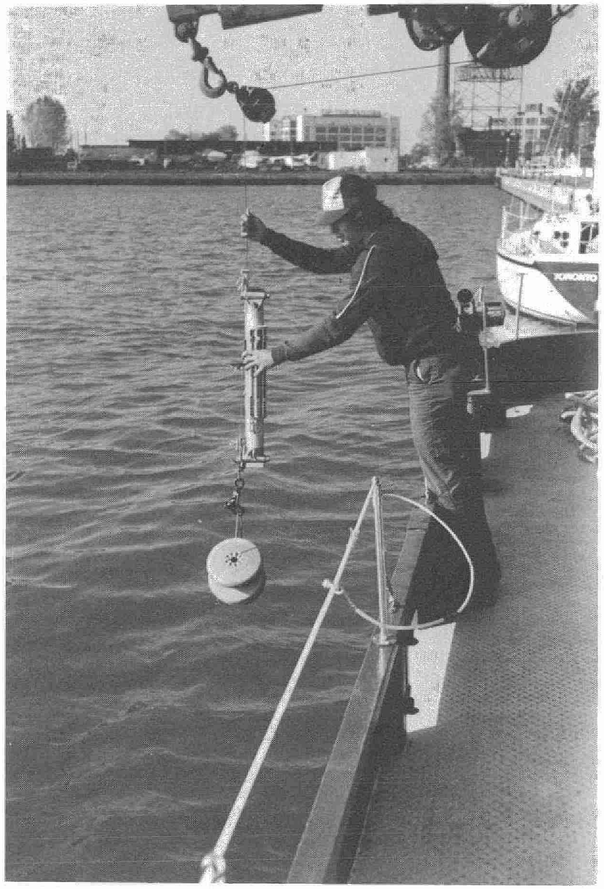
All transects have been set up perpendicular to the shoreline with stations selectively located along depth contours of 4, 8, 12, 16, 32 and 50 metres. In 1979, there were approximately 180 stations in the nearshore area between the Niagara River mouth and Oshawa. Station locations for the 1976-1979 period are presented in Appendix B.

The offshore region of Lake Ontario is monitored by the Federal Department of the Environment.

Sampling Procedures

Sampling commences each spring soon after the onset of the thermal bar. Surface (1.5 metres) samples are taken in triplicate runs at each of the designated stations. A table summarizing sampling periods for each survey component (run) is presented in

Appendix B. All samples are treated in compliance with standard procedures outlined in the Ministry publication entitled "A Guide to the Collection and Submission of Samples for Laboratory Analysis". In the laboratory, the samples are analyzed for a set of parameters designed to assess the trophic status of the waters. In addition, temperature, dissolved oxygen, pH and secchi depth readings are taken in the field. A summary of all parameters now available on the SIS system for the 1976-1979 period is given in Appendix B. Please note that a majority of these, but not all, have been mapped out in this Atlas.



above
The Nansen bottle is often employed in the collection of water samples.

left
Certain analyses, such as dissolved oxygen, require immediate on-board determinations.

DATA ANALYSIS

This Atlas presents both spatial and temporal summaries of Lake Ontario nearshore water quality data.

Regional Water Quality

Regional differences in water quality have been determined through a statistical procedure [1] which has partitioned the nearshore band into statistically different areas. A regression model was used to separate the temporal (between replicate runs) variability from spatial (between station) variability. All data, with the exception of temperature (which was plotted as isotherms), were subjected to this grouping model and subsequently presented pictorially in the accompanying maps (Appendix C).

All nearshore stations, with the exception of those located at river mouths and in small harbours, were used in the analysis. Because of their high variability, river mouth and small harbour stations were excluded from the grouping analysis. On the other hand, the two largest harbours on the lake, Toronto and Hamilton, have been included in the grouping model,by using their centrally located stations. It should be borne in mind, however, that these stations represent a conservative estimate of water quality in these two harbours and do not reflect the spatial differences existing within the harbours themselves. For further information on Toronto and Hamilton Harbours please refer to the series of Ministry reports dealing specifically with these bodies of water.

The coloured maps represent the spatial variability inherent in the nearshore areas during spring conditions. The levels of a variable in question are statistically similar within each of the designated zones while at the same time being significantly different from those in all other zones. Please note that although the mean concentrations characterizing each zone are obviously different from each other, the ranges between the zones occasionally overlap as a result of transformation procedures necessitated by the statistical analyses.

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(1) A.H. El-Shaarawi and R.E. Kwiatkowski. A model to describe the inherent spatial and temporal variability of parameters in Lake Ontario 1974. J. Great Lakes Res., December 1977.

Temporal Water Quality

Changes occurring within the nearshore areas of Lake Ontario over the last thirteen years (1967-1979) have been documented (Appendix A) through linear regression analyses performed on spring data collected in the following four regions: Niagara to Jordan harbour, Jordan harbour to Oakville, Oakville to Ashbridges Bay and Asbridges Bay to Ajax. These areas were chosen on the basis of regional differences observed through the statistical analyses previously discussed. The linear regression chosen to assess the temporal trends was thus based on spring arithmetic means of all stations sampled within each area with the exception of stations located at input sources. These stations were deleted from the trend analyses in order to minimize small scale localized effects and reduce variability and scatter in the data. The statistical significance of the computed regression line was tested through an analysis of variance at a 95% confidence level.

Temporal water quality trends are not only a function of the loading regime but also reflect the effect of environmental factors which govern the response of the nearshore zone. Thus, anticipated changes in nearshore water quality, as a result of abatement measures, are not always clearly apparent due to data scatter and varying environmental conditions experienced from one year to the next. Consequently, interpretation of temporal trends should be done in conjunction with a consideration of supporting variables as well as a good understanding of factors governing the variability of the parameter in question.

For example, apparent increases in chlorophyll a may not be necessarily a function of increased phosphorus inputs but may simply reflect lower water levels or higher water temperatures prevailing at the time of sampling. Consequently, in-depth interpretations of temporal trends must take into account not only the loading regime but also such factors as precipitation, water temperatures, water levels, thermal bar advance and ultimately, the residence time of the load. A brief synopsis dealing with some of the factors governing the temporal variability of selected water quality parameters is presented in the following table to familiarize the reader with the complexity of temporal trend interpretation. Due to the non-scientific nature of this publication, only a limited number of responses to environmental factors are dealt with.

FACTORS RESPONSIBLE FOR VARIABILITY IN SELECTED WATER QUALITY INDICATORS

	RESPONSE TO ENVIRONMENTAL FACTORS			
WATER QUALITY VARIABLE	INHERENT VARIABILITY	TEMPERATURE	WATER LEVELS	PRECIPITATION
NH_3, NO_2, NO_3	High variability, a function of the Nitrogen Cycle transformations, including N immobilization, mineralization, nitrification and denitrification.	Complex effect since temperature has a marked influence on N regeneration, turnover and assimilation processes.	Complex effect.	Complex effect.
REACTIVE SILICATE	High variability, a function of biological assimilation rates, especially in presence of diatoms.	Since this variable is biologically active, temperature has an effect on reaction rates.	During high water level years, increased shoreline erosion may contribute silicates to the water.	Complex effect.
HETEROTROPHIC BACTERIA	High variability, a function of bacterial growth patterns.	An increase in water temperature often stimulates bacterial cell division leading to higher heterotroph populations.	Complex effect.	Higher nutrient loadings associated with runoff conditions may enhance growth of heterotrophic bacteria.

FACTORS RESPONSIBLE FOR VARIABILITY IN SELECTED WATER QUALITY INDICATORS

	RESPONSE TO ENVIRONMENTAL FACTORS			
WATER QUALITY VARIABLE	INHERENT VARIABILITY	TEMPERATURE	WATER LEVELS	PRECIPITATION
CONDUCTIVITY	Moderate variability a function of inputs such as rivers, shoreline erosion etc.	Probably little effect.	During high water level years, increased shore-erosion may contribute to higher conductivity levels.	Higher conductivity often is associated with storm events.
CHLOROPHYLL *a*	Moderate to high variability, a function of algal growth patterns.	An increase in water temperature stimulates algal growth resulting in higher chlorophyll *a* levels.	Low water levels in certain instances may change the mean nearshore water depth leading to an alteration in spring warming patterns and a shift in spring algal bloom occurrence.	Higher input loadings as a result of runoff may increase levels of available nutrients and thus enhance algal growth.
SECCHI DEPTH	High variability, a function of suspended sediments, algae, etc.	Higher temperatures may stimulate algal blooms resulting in low Secchi depth readings.	During high water level years, increased shoreline erosion may contribute to high suspended solid content in the water and consequently low Secchi depth readings.	Runoff-associated loadings may contribute to higher suspended solid content and consequently lower Secchi depth readings. Also see: chlorophyll *a*.
FILTERED REACTIVE PHOSPHORUS	Moderate to high variability, partly a function of biological assimilation - excretion rates.	Since this variable is biologically active, temperature has an effect on reaction rates.	Complex effect.	Runoff-associated loadings may contribute to increased concentrations in water.

SIGNIFICANCE OF WATER QUALITY VARIABLES

One of the chief aims of the Ministry of the Environment's nearshore surveillance program is to monitor the effectiveness of phosphorus removal programs by assessing the trophic status of the nearshore waters. This is accomplished largely through the monitoring of phosphorus and chlorophyll a levels in the nearshore region. Since phosphorus has been shown to be an important limiting factor for phytoplankton growth, cultural eutrophication, or the increase in the input rate of nutrients (notably phosphorus) from human activities, has been singled out as the prime cause of biomass increases in the Great Lakes. Cognizant of the relationship between phosphorus and eutrophication, the water management strategies encompassed in the Great Lakes Water Quality Agreement of 1978 signed by the United States of America and Canada included provisions for stringent controls on phosphorus loadings arising from human sources.

A brief description, emphasizing the importance of trophic indicators and supportive variables chosen for presentation in this Atlas, is given below. The reader is urged to supplement this discussion by referring to a booklet entitled "Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment", published in November, 1978.

Temperature

Water temperature is important, and at times critical, for many uses of water. It determines the solubility of gases, directly affects biological and chemical reaction rates and equilibria and governs the suitability of waters as an habitat for aquatic life. An understanding of the thermal structure prevailing during the spring period is essential for proper interpretation of water quality information presented in this Atlas. Of prime importance is the presence of the thermal bar which is defined as a $4^{o}C$ transition zone between the warmer nearshore waters and the colder mid-lake waters. Since water density is greatest at $4^{o}C$, the thermal bar serves

as a density barrier which impedes mixing of nearshore water masses with the open lake. As a result, the effect of shore inputs on nearshore water quality is accentuated and plumes arising from direct discharges become well defined.

Conductivity (Specific Conductance)

The determination of specific conductance is a method of measuring the ionic strength of water. Ionized chemical compounds present in surface waters either naturally, or as a result of man's activities, include: calcium, magnesium, sodium, bicarbonate, carbonate, chloride, nitrate, nitrite and sulphate. Since there is a direct correlation between the total concentration of ionic species dissolved in water and specific conductance, this parameter is a sensitive, although indirect indicator of water quality changes.

Secchi Depth

A Secchi depth reading is a measure of water clarity. A Secchi disk is a black and white disk, 20 cms in diameter, which is lowered into the water column to a depth at which it is just visible. The Secchi depth measurement can be used to estimate the depth to which white light penetrates the water column and can still be usable by algae for photosynthesis and growth. This usable light depth is roughly calculated to be twice the Secchi depth. Factors responsible for low Secchi depth readings are suspended and colloidal matter including sediment particles, algal cells and inorganic detritus as well as colour. Most often, low Secchi depth readings are caused by algal blooms or suspended solid inputs from erosion, landfilling, dredging, river runoff and/or industrial inputs.

Chlorophyll a

Chlorophyll a is a green photosynthetic pigment common to all algal groups. Because of its ubiquity in algae, chlorophyll a can be used as an indirect measure of algal densities present in the water. More specifically, chlorophyll a levels provide an appropriate measure of algal biomass which can then be used to assess the effectiveness of nutrient removal programs as well as to determine the relative trophic status of the waters. Although a universally acceptable trophic classification based on

chlorophyll *a* is still being developed, some authors[1] have set the following arbitrary limits as guidelines:

eutrophic waters - chlorophyll *a*: >8.8 ug/L
mesotrophic waters - chlorophyll *a*: 4.4 - 8.8 ug/L
oligotrophic waters - chlorophyll *a*: <4.4 ug/L

Major problems associated with high algal populations include taste and odour in drinking water supplies, clogging of water intake filters, oxygen depletion, alteration of aquatic habitat, and aesthetic impairment. Only infrequent and isolated instances of these problems have taken place in Lake Ontario nearshore areas thus far.

Phosphorus (Total and Filtered Reactive)

Phosphorus is an essential nutrient for all living systems including algae. Total phosphorus is a measure of phosphorus content in a water sample and consists of phosphorus found in dissolved forms as well as in organic forms, including the algae themselves. To avoid nuisance concentrations of algae in lakes, it is suggested that the average total phosphorus concentrations during the ice-free period should not generally exceed 20 ug/L. Filtered reactive phosphorus is comprised largely of orthophosphates, which are considered to be the forms of phosphorus available for assimilation and growth by algae. Sources of phosphorus to lakes are: untreated and treated sewage, some industrial wastes, urban stormwater, agricultural drainage, and direct precipitation.

It is widely believed that a reduction in phosphorus input into the Great Lakes will result in decreased algal populations and minimization of associated eutrophication problems. Provisions for control of phosphorus are outlined in detail in the "Great Lakes Water Quality Agreement of 1978", signed by Canada and the United States of America.

Nitrogen (Organic Nitrogen, Ammonia, Nitrate, Nitrite)

Nitrogen is an essential element required by all biological systems including algae. The principle forms of nitrogen occurring in aquatic ecosystems are ammonia (NH_3-N), nitrate (NO_3-N), nitrite (NO_2-N) and organic nitrogen. Total Kjeldahl nitrogen includes nitrogen present in the organic form and as free ammonia.

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[1] Dobson, H.F.H., M. Gilbertson and P.G. Sly. A summary and comparison of nutrients and related water quality in lakes Erie, Ontario, Huron and Superior. J. Fish Res. Board Can. 31: 731-738.

Organic nitrogen is an essential constituent of protein in all living organisms, including algae. All inorganic forms of nitrogen (NH_3-N, NO_3-N, NO_2-N) are available to algae for assimilation and growth, with preferential uptake exhibited towards ammonia. The concentration of various nitrogen forms in water is the result of complex interactions, including mineralization, nitrification, and denitrification. Consequently, since the levels of inorganic nitrogen forms exhibit considerable variability, caution must be exercised in all data interpretation and especially in that pertaining to temporal trend analysis.

Principle sources of nitrogeneous compounds include municipal waste inputs (largely NH_3), drainage from fertilized agricultural areas (mainly NO_2 and NO_3) and processed waste from chemical and steel plants (NH_3, NO_2 and NO_3).

Reactive Silicate

Silicate is essential for the growth of diatoms and some species of Chrysophyceae and Xanthophyceae but probably not for most other groups of algae. The assimilation of silicates by diatoms is directly connected with the formation of new cell walls following cell division. Spring diatom blooms tend to deplete epilimnetic waters of silica, with the result that diatoms usually do not come back into dominance until fall overturn which results in silica replenishment from hypolimnetic waters.

Heterotrophic Bacteria

Heterotrophic bacteria are a group of micro-organisms that require some form of organic carbon for their growth, as opposed to the rest of the bacterial community which is capable of surviving solely on inorganic substrates. Populations of heterotrophic bacteria reflect the availability of organic nutrient sources, and thus densities of these organisms in eutrophic waters are generally much higher than those found in oligotrophic waters.

GLOSSARY

ALGAE	-	a group of aquatic plants which may be unicellular or multicellular and range from microscopic (most phytoplankton) to macroscopic (eg. Cladophora, a large filamentous alga which is sometimes found in mats growing or accumulating along shorelines).
AREAL	-	spatial
BLOOM	-	a sudden increase in the abundance of algal populations.
CHRYSOPHYCEAE	-	a class of algae, usually brown in colour.
COLLOIDS	-	very small particles which tend to remain suspended and dispersed in liquids.
CONFIDENCE LEVEL	-	The probability (expressed as a percentage) that a tested statistical relationship is true.
DIATOMS	-	a class of algae which possess a cell wall consisting of two distinct halves impregnated with silica.
DOWNWELLING	-	see UPWELLING.
EPILIMNION	-	see STRATIFICATION.
EUTROPHICATION	-	an increase in the input rate of nutrients into a body of water with a resultant increase in biomass.
EUTROPHIC	-	see TROPHIC STATE.
GEOMETRIC MEAN	-	an antilog of the mean of logarithmically transformed data.
GRID	-	a network of stations forming the basis of map references.
HYPOLIMNION	-	see STRATIFICATION
ISOTHERM	-	a line joining equal values of temperatures.

LINEAR REGRESSION - relation of one variable to another expressed as a straight line

MEAN - an average defined as the sum of all observations divided by the number of observations.

MESOTROPHIC - see TROPHIC STATE.

pH - a measure of the hydrogen ion content of water on an alkalinity-acidity scale. Neutral waters have pH7, acidic less than pH7 and alkaline greater than pH7.

PLUME - a zone of influence associated with a point source discharging into a body of water.

SEICHE - a standing wave in a lake manifested by periodic oscillation of water, commonly set up by prolonged uni-directional winds.

THERMAL STATIFICATION - a partitioning of a water column into distinct thermal layers. Following spring warm-up, the lake becomes divided into the following three regions which are strongly resistant to mixing with each other: Epilimnion - a warmer upper stratum, Thermocline - a thermal gradient zone which represents the transition between the upper warm waters and a lower cold layer, Hypolimnion - a colder lower layer.

THERMAL BAR - a narrow transition zone consisting of a nearly vertical 4^{o} centigrade isotherm which develops in the spring and separates the warmer nearshore waters from colder open water masses.

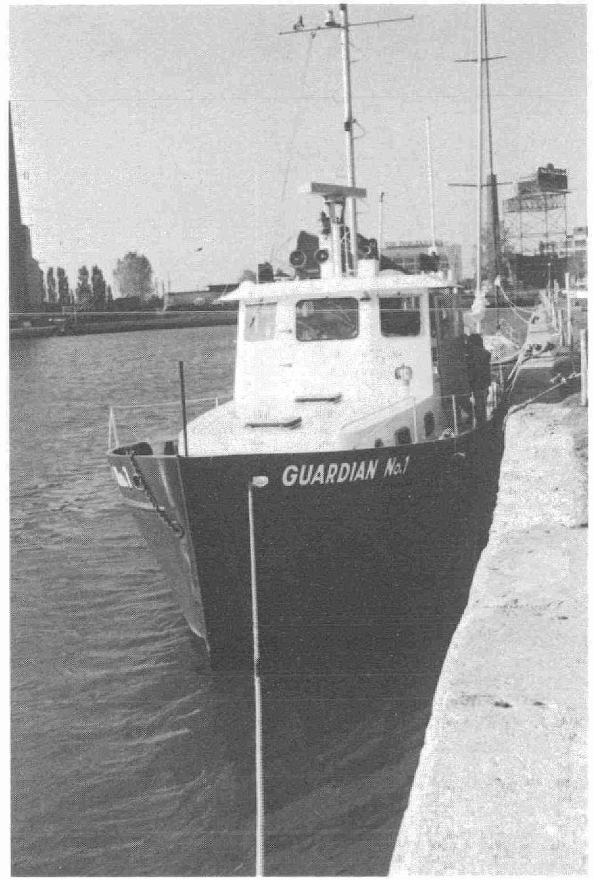
TRANSECT - a line, perpendicular to the shoreline, along which stations have been selected.

TROPHIC STATE - a classification of water bodies based on their supply of nutrients. Eutrophic waters have a good supply of nutrients and therefore are capable of rich biological production. Mesotrophic waters are

intermediate in characteristics between eutrophic and oligotrophic waters. Oligotrophic waters are poorly supplied with nutrients and support limited biological production.

UPWELLING - a forcing of hypolimnetic waters toward the surface, brought about by the tilting of the thermocline as a result of prolonged uni- directional wind stresses. An upwelling occurring along a nearshore area nearly always takes place simultaneously with a downwelling on the opposite shore. A downwelling is a displacement of hypolimnetic waters by warmer epilimnetic waters.

XANTHOPHYCEAE - a class of algae often (yellow) green in colour.



Well-equipped ships, such as the Guardian No.1, are used in surveillance and monitoring of the Great Lakes.

SYMBOLS AND ABBREVIATIONS

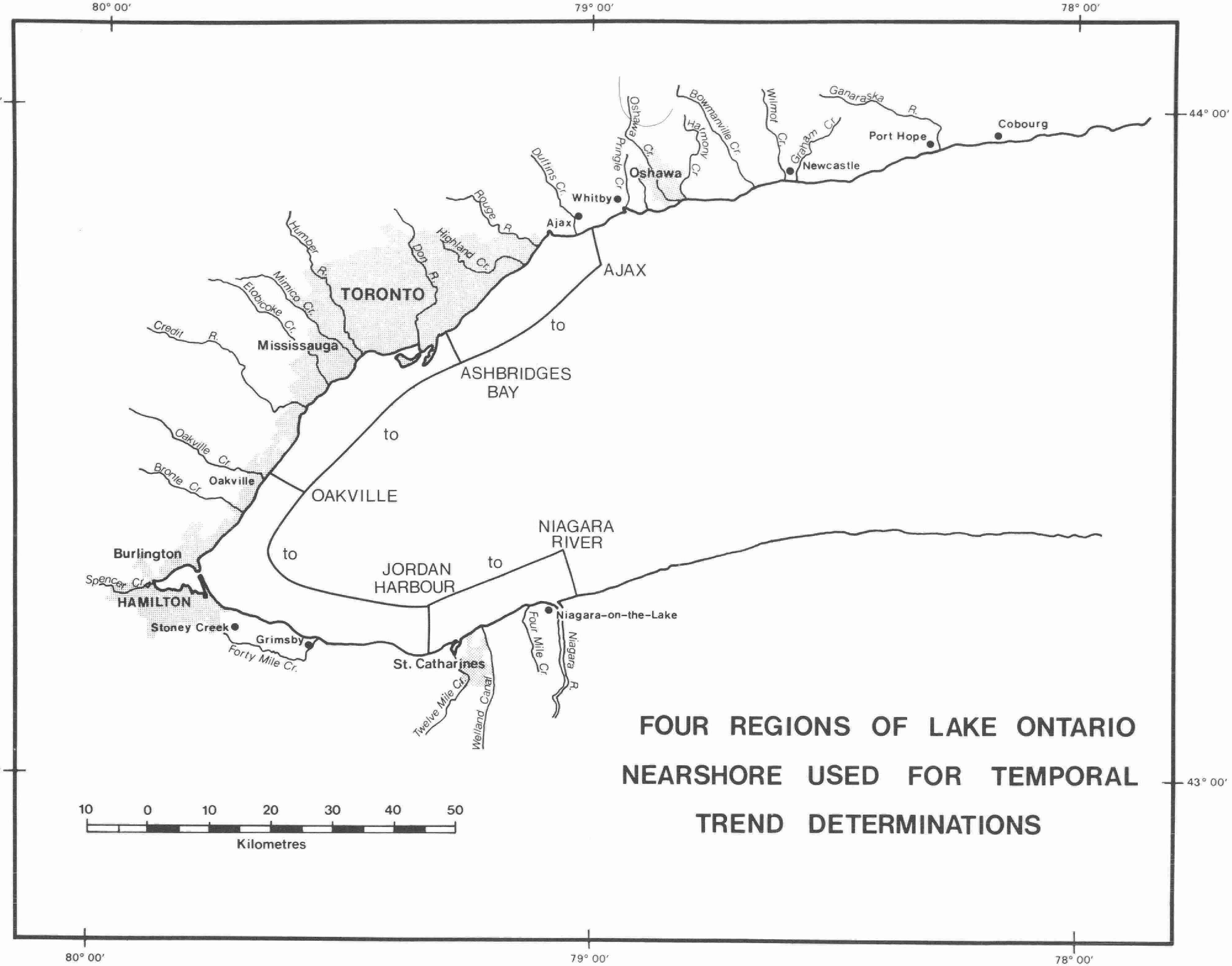
QUALIFIERS

<	less than
>	greater than

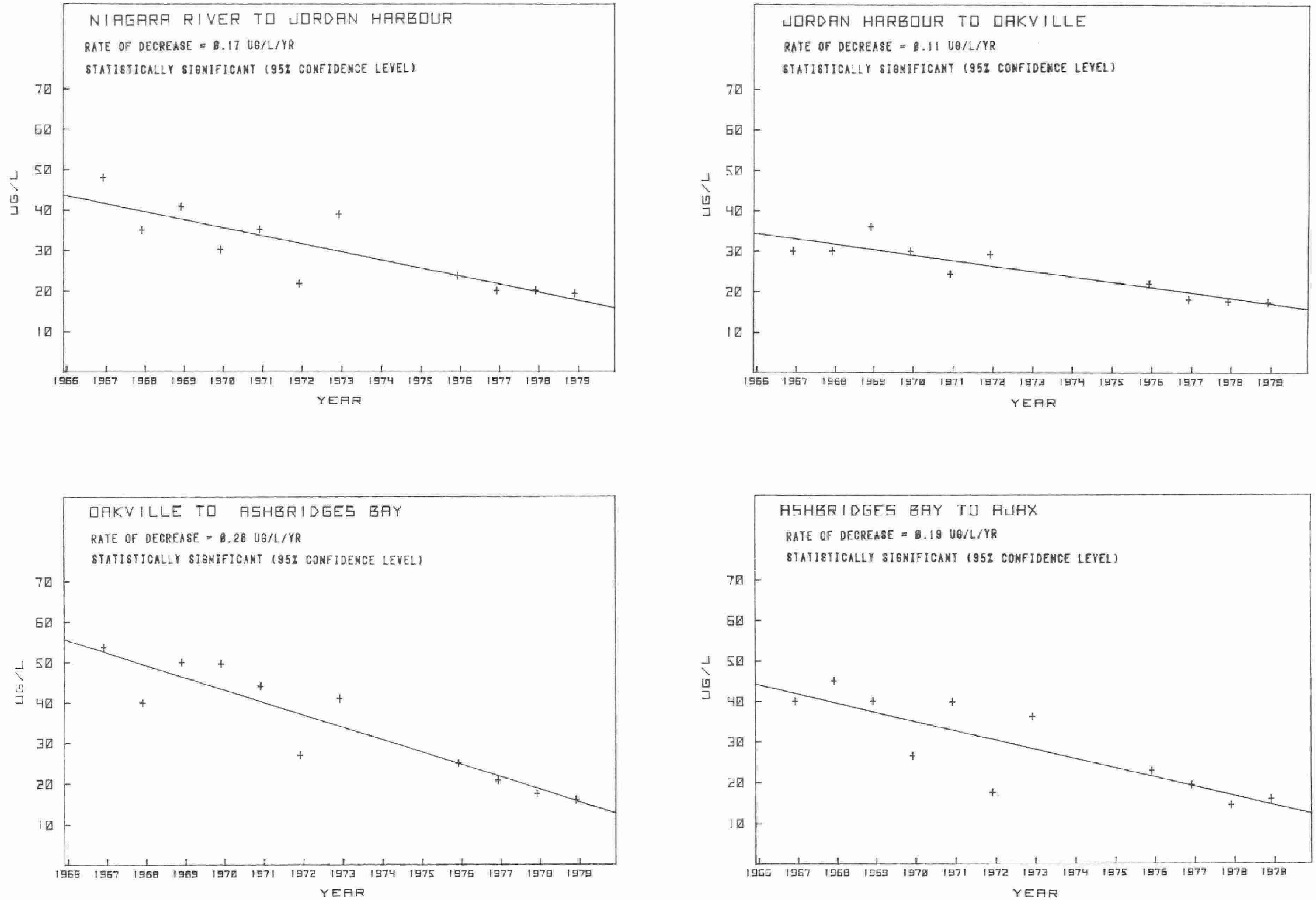
UNITS

m	meters
mg/L	milligrams per litre
ug/L	micrograms per litre
uS/cm	microsiemens per centimetre
FTU	Formazin Turbidity Units
^{o}C	Degrees Celsius (centigrade)

APPENDIX A

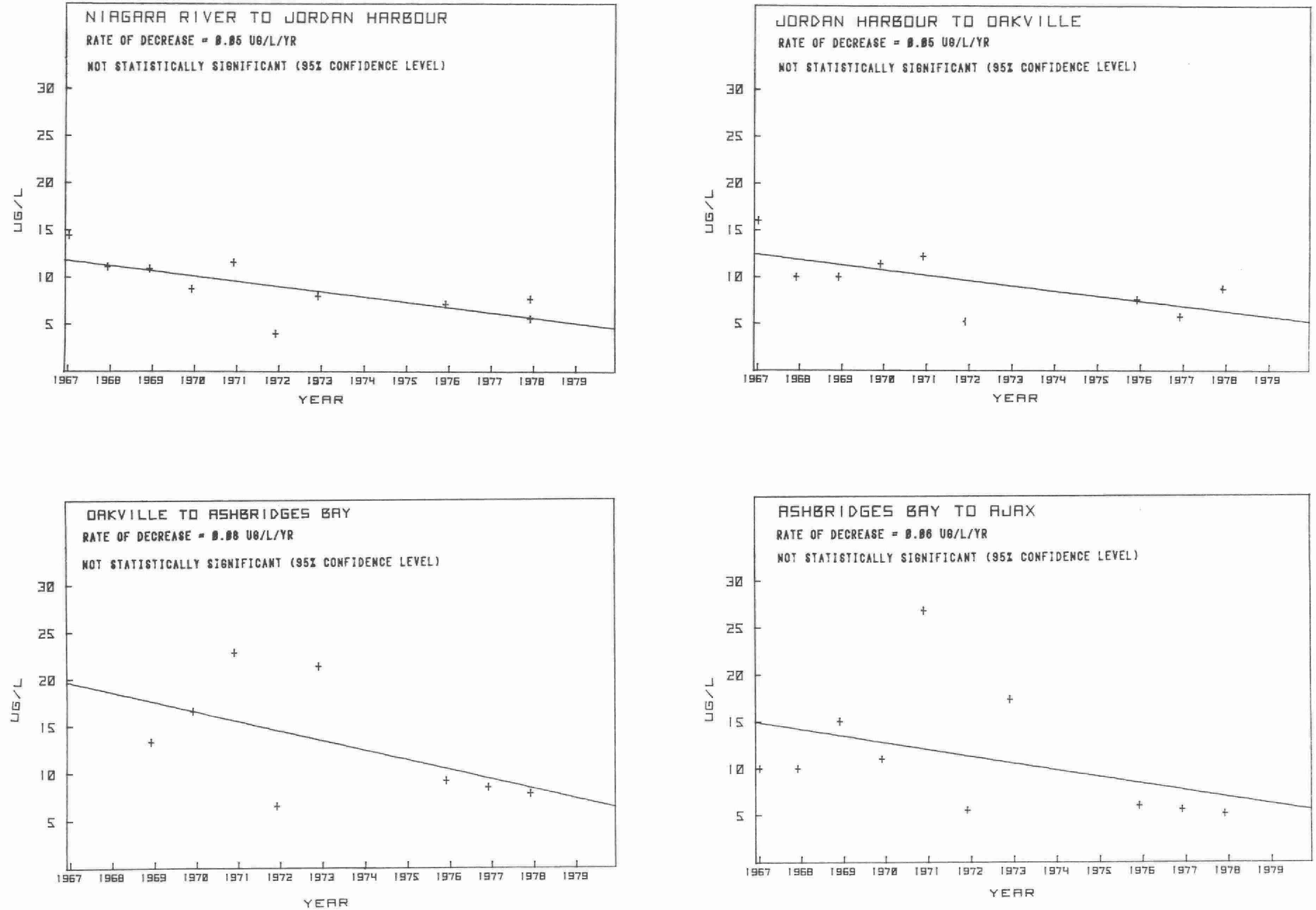


FOUR REGIONS OF LAKE ONTARIO NEARSHORE USED FOR TEMPORAL TREND DETERMINATIONS

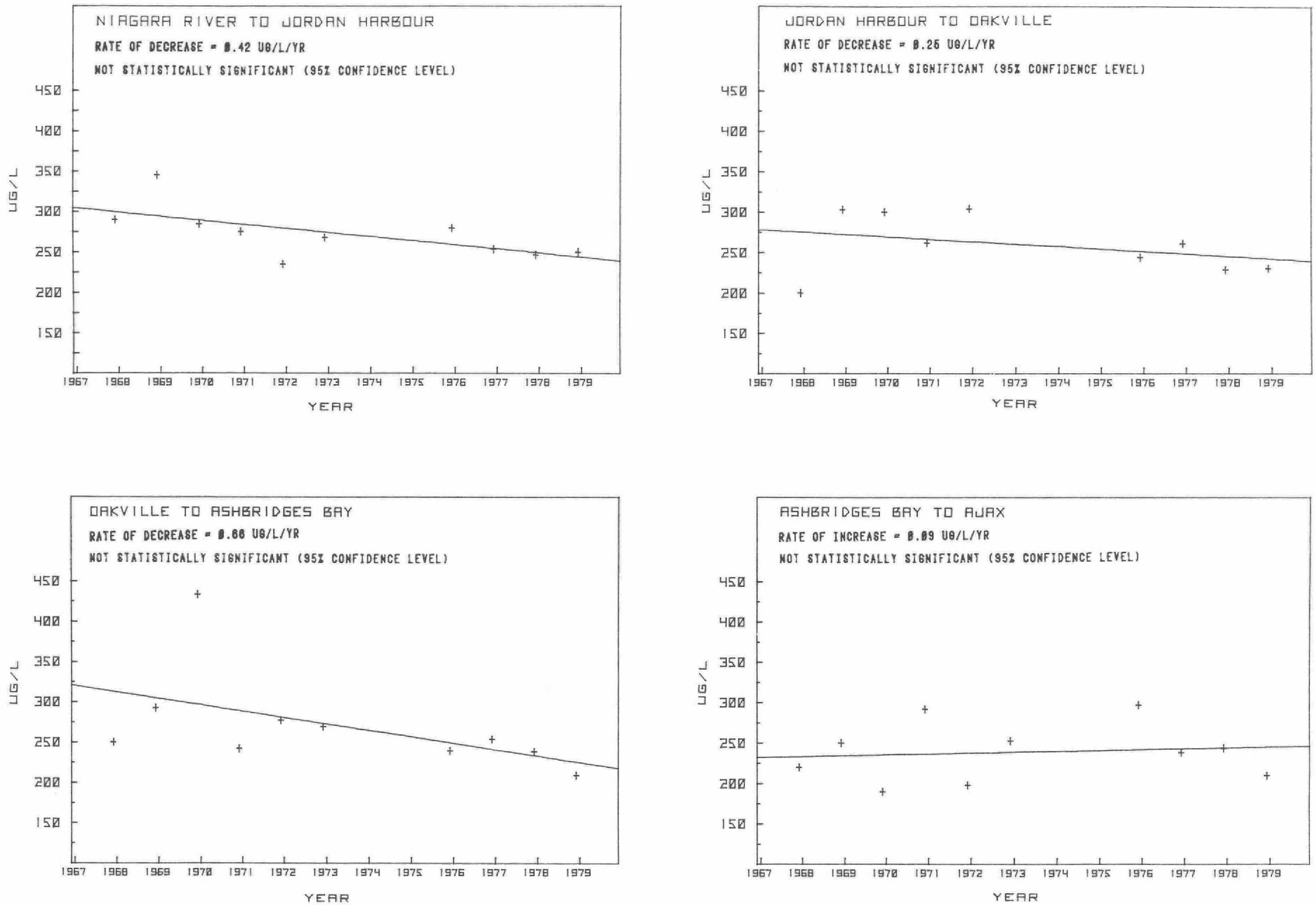


TOTAL PHOSPHORUS

TEMPORAL TRENDS IN FOUR REGIONS OF L. ONTARIO NEARSHORE

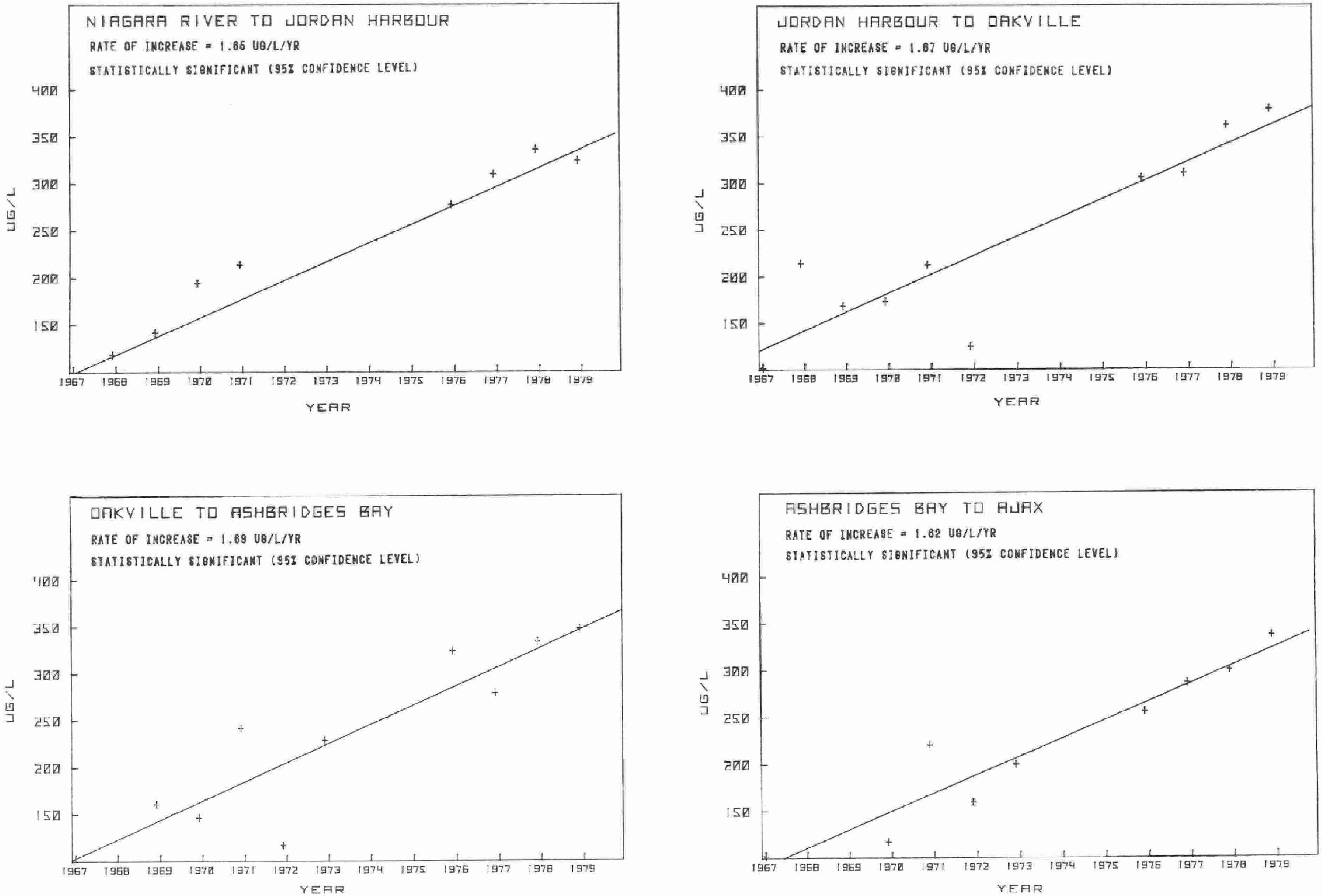


FILTERED REACTIVE PHOSPHORUS
TEMPORAL TRENDS IN FOUR REGIONS OF L. ONTARIO NEARSHORE



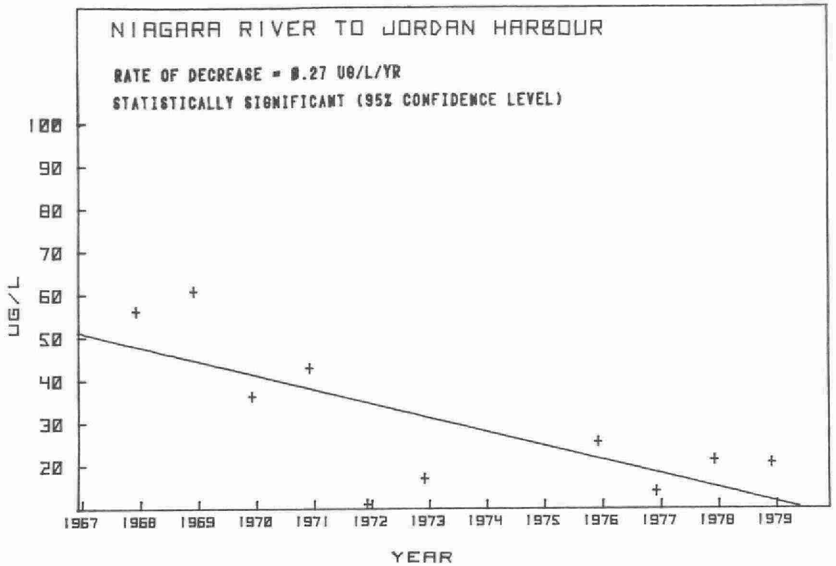
ORGANIC NITROGEN

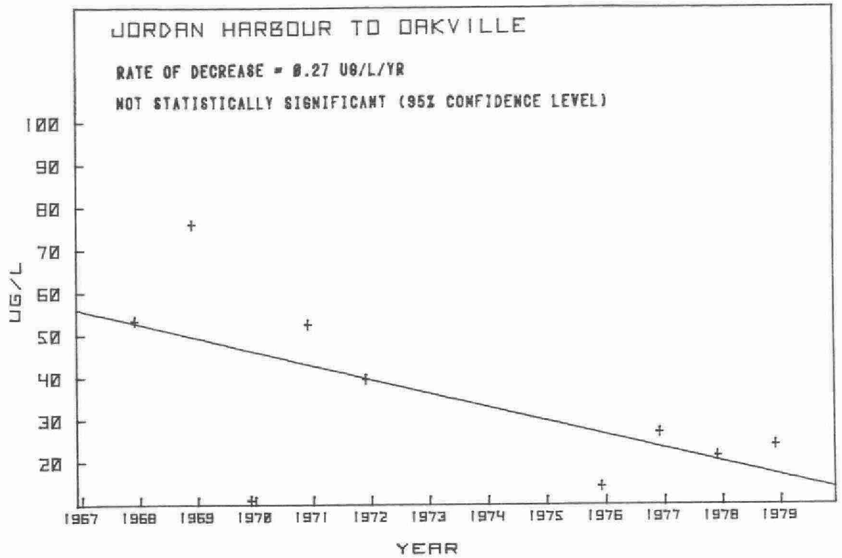
TEMPORAL TRENDS IN FOUR REGIONS OF L. ONTARIO NEARSHORE

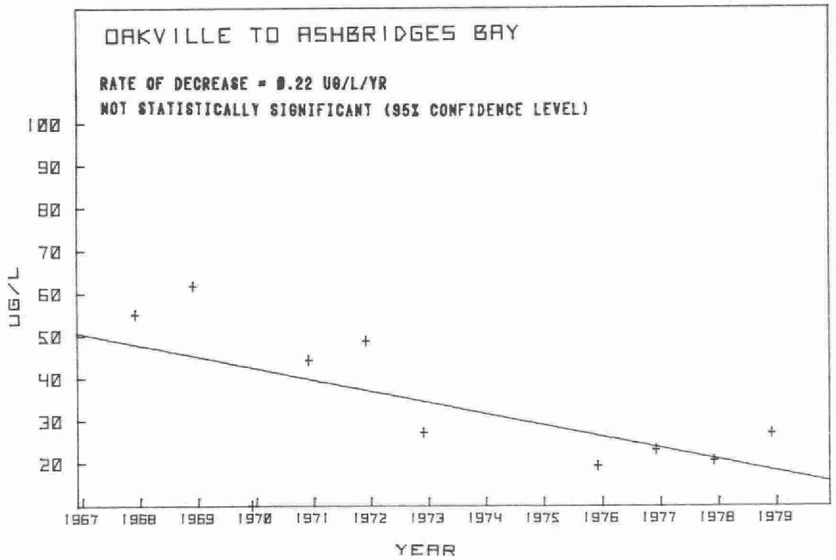


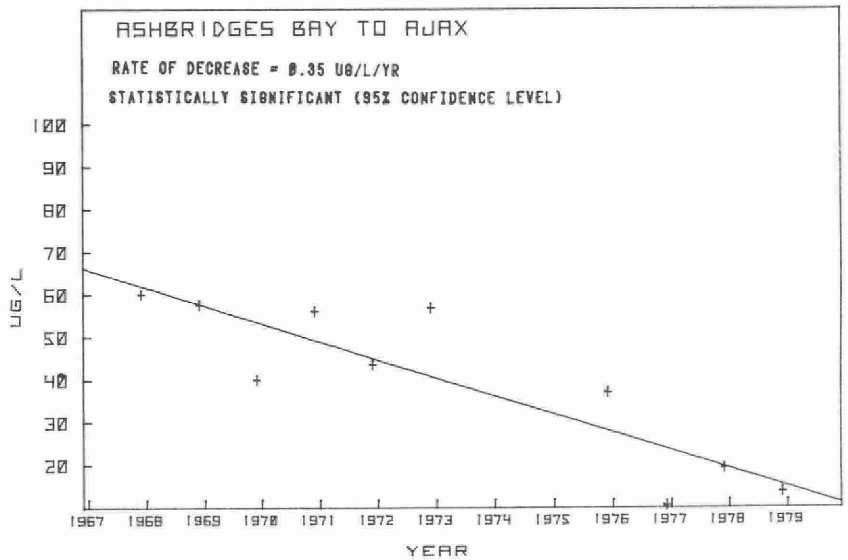
NITRITE + NITRATE

TEMPORAL TRENDS IN FOUR REGIONS OF L. ONTARIO NEARSHORE



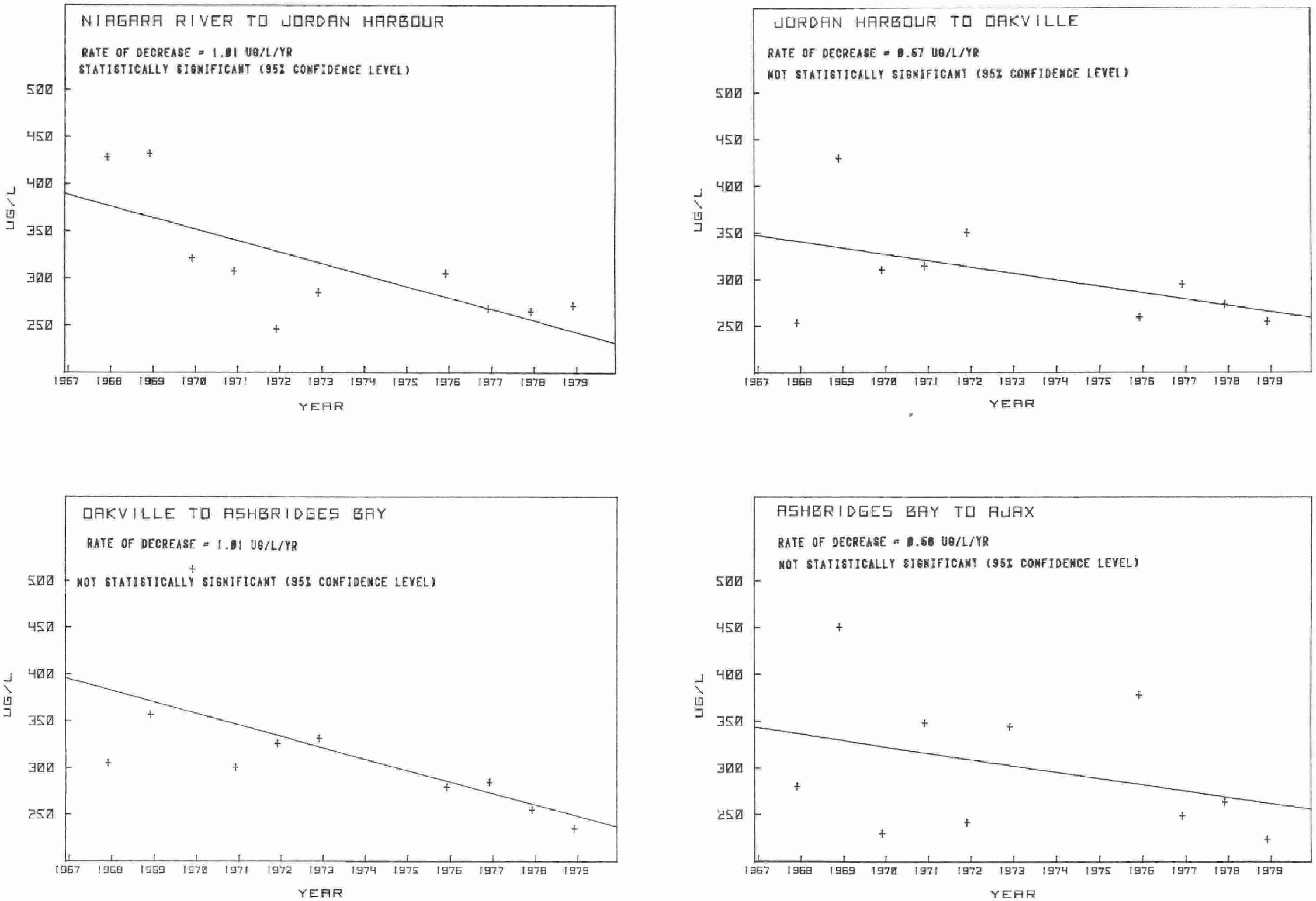






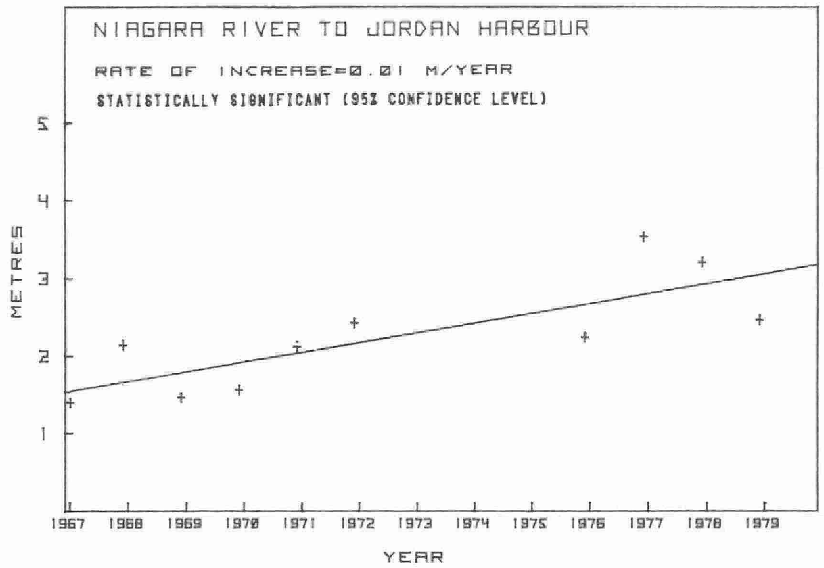
AMMONIA

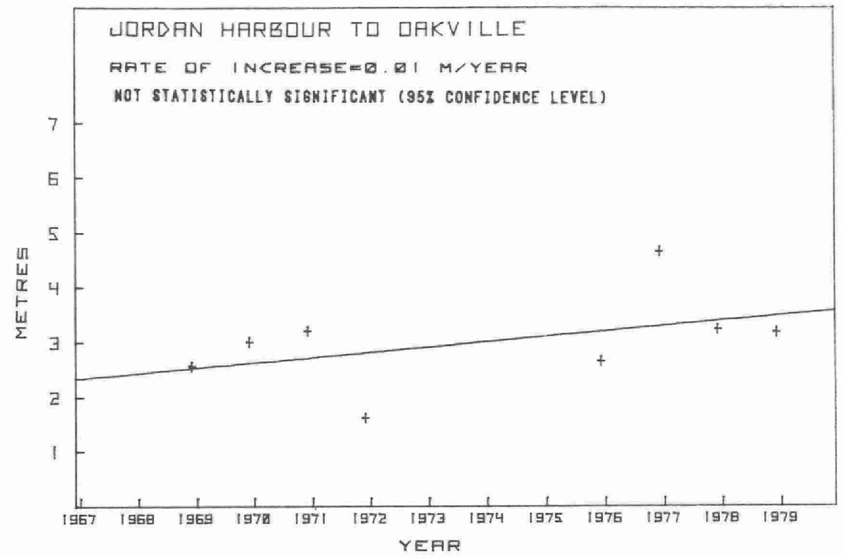
TEMPORAL TRENDS IN FOUR REGIONS OF L. ONTARIO NEARSHORE

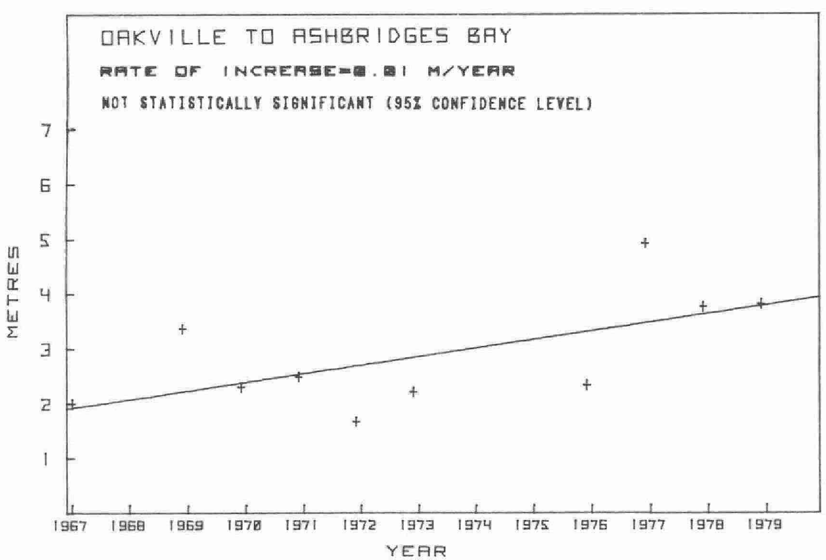


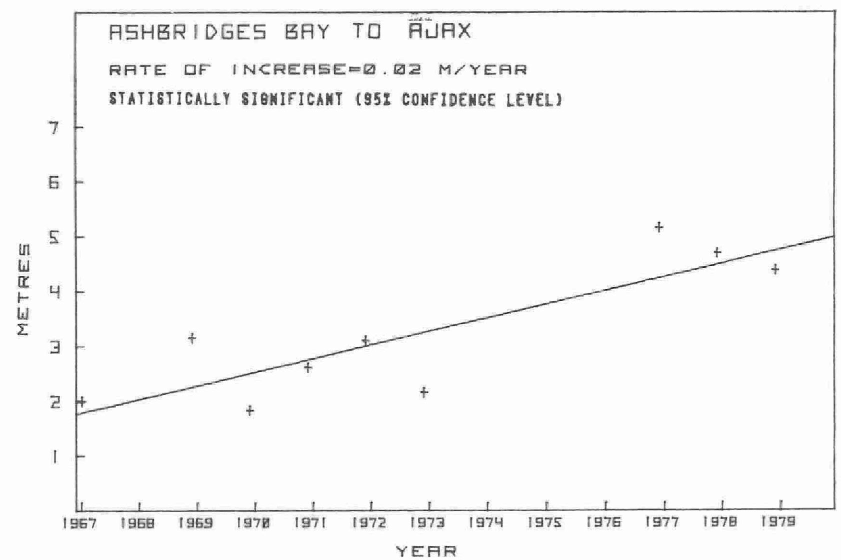
TOTAL KJELDAHL NITROGEN

TEMPORAL TRENDS IN FOUR REGIONS OF L. ONTARIO NEARSHORE

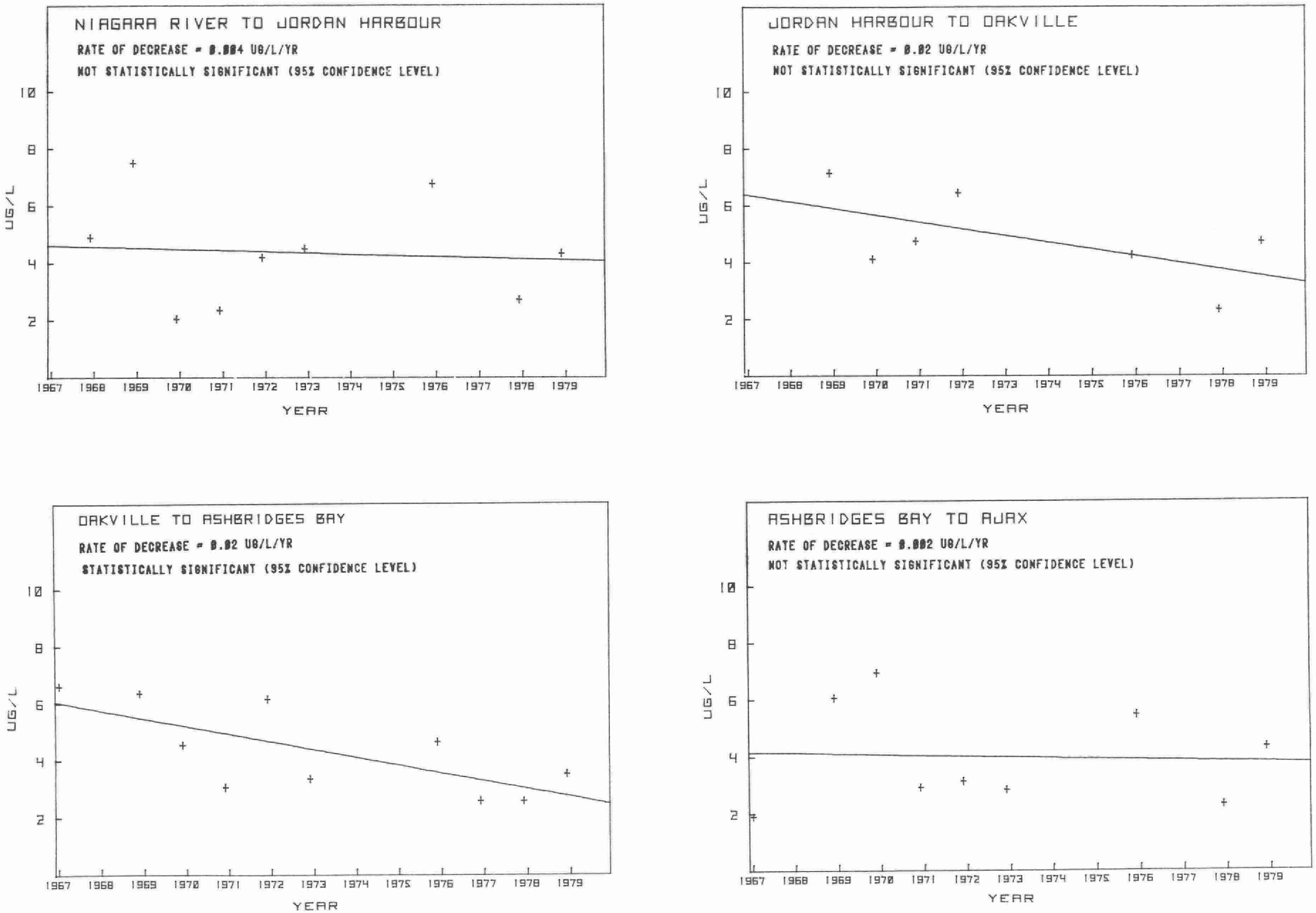






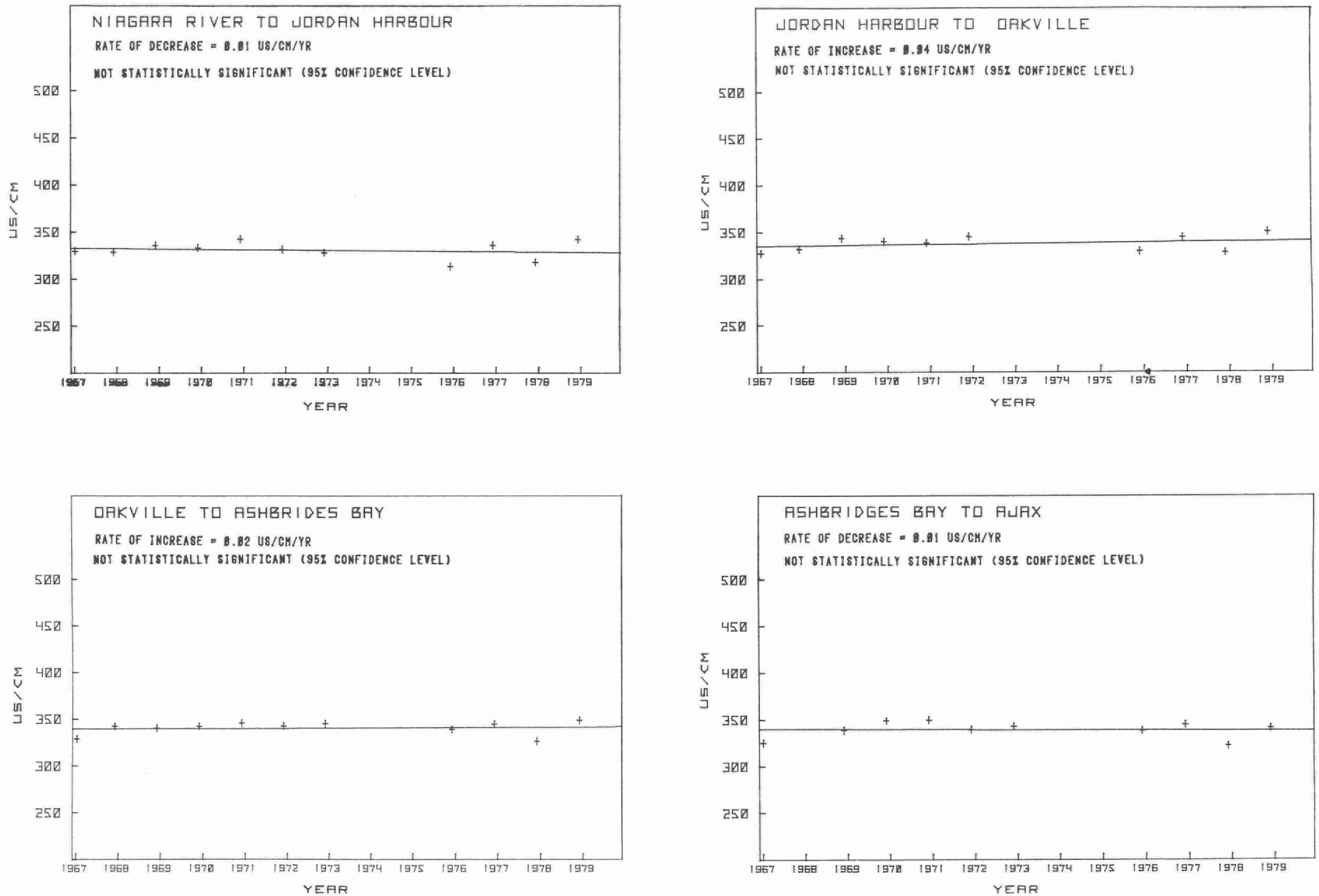


SECCHI DISK DEPTH
TEMPORAL TRENDS IN FOUR REGIONS OF L. ONTARIO NEARSHORE



CHLOROPHYLL a

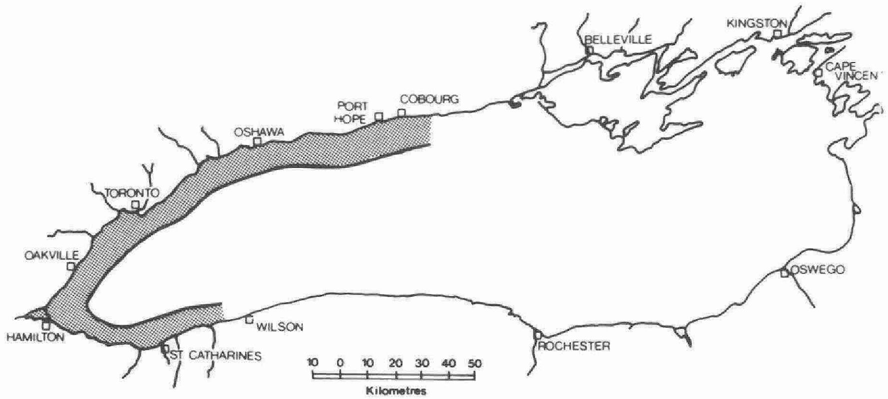
TEMPORAL TRENDS IN FOUR REGIONS OF L. ONTARIO NEARSHORE



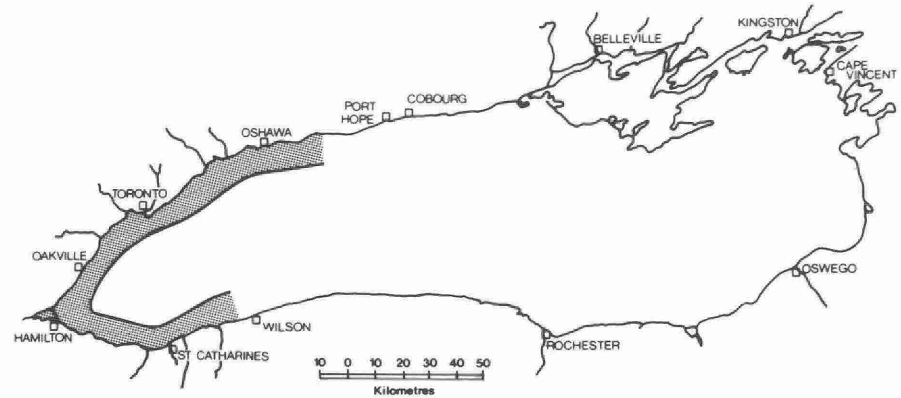
CONDUCTIVITY

TEMPORAL TRENDS IN FOUR REGIONS OF L. ONTARIO NEARSHORE

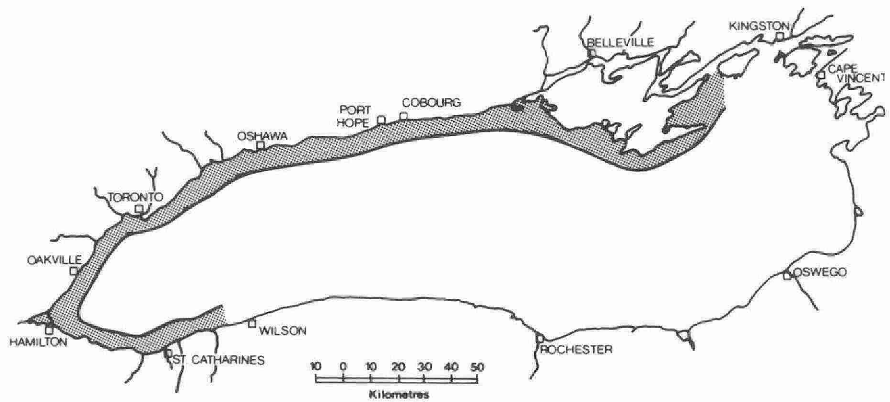
APPENDIX B



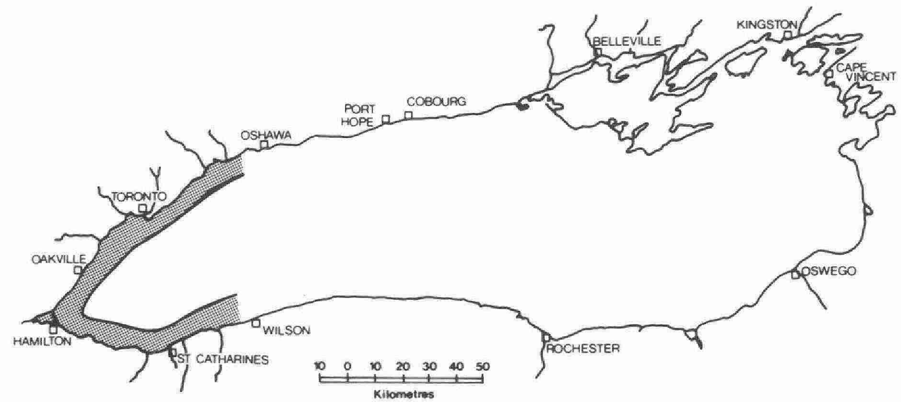
1976



1977

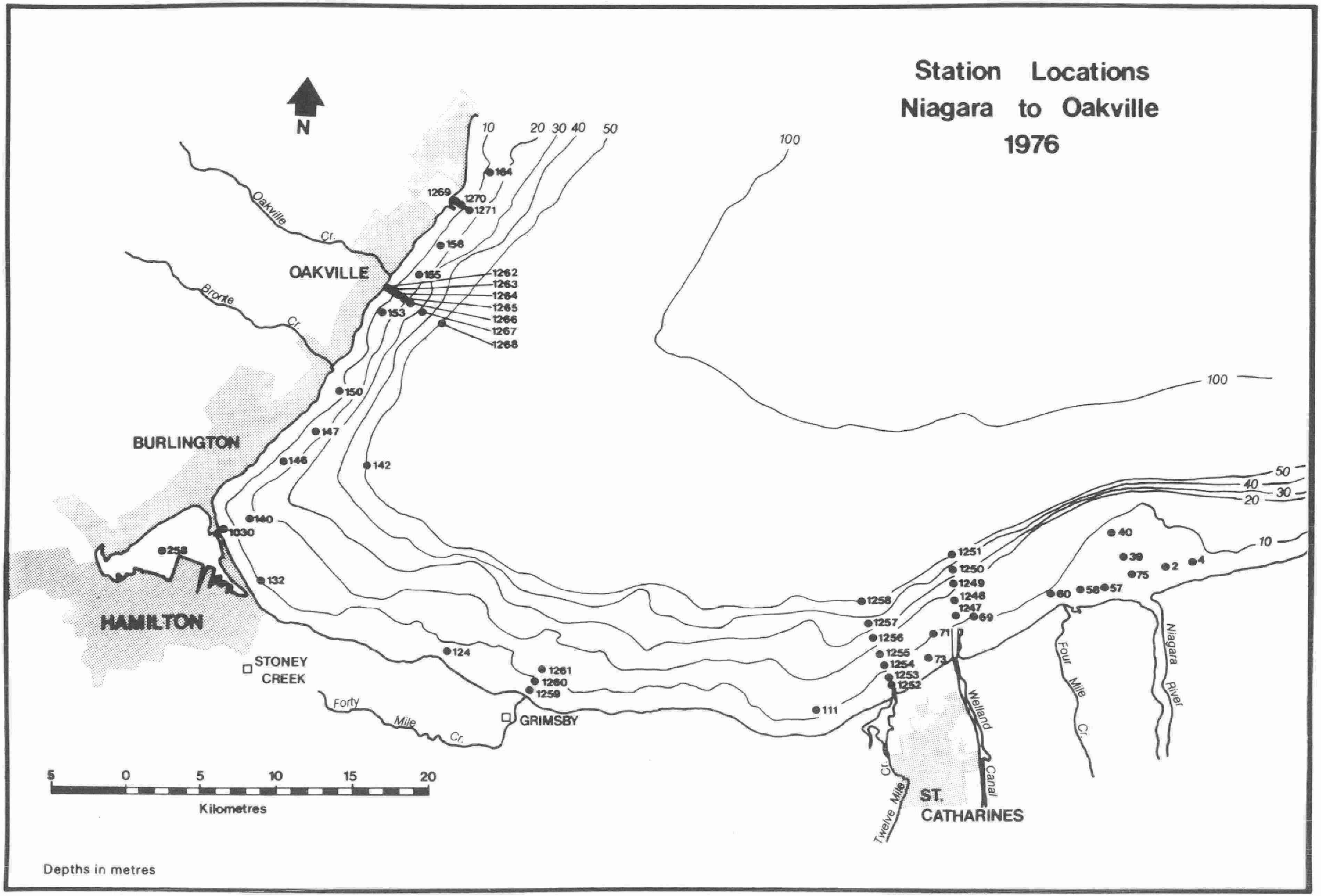


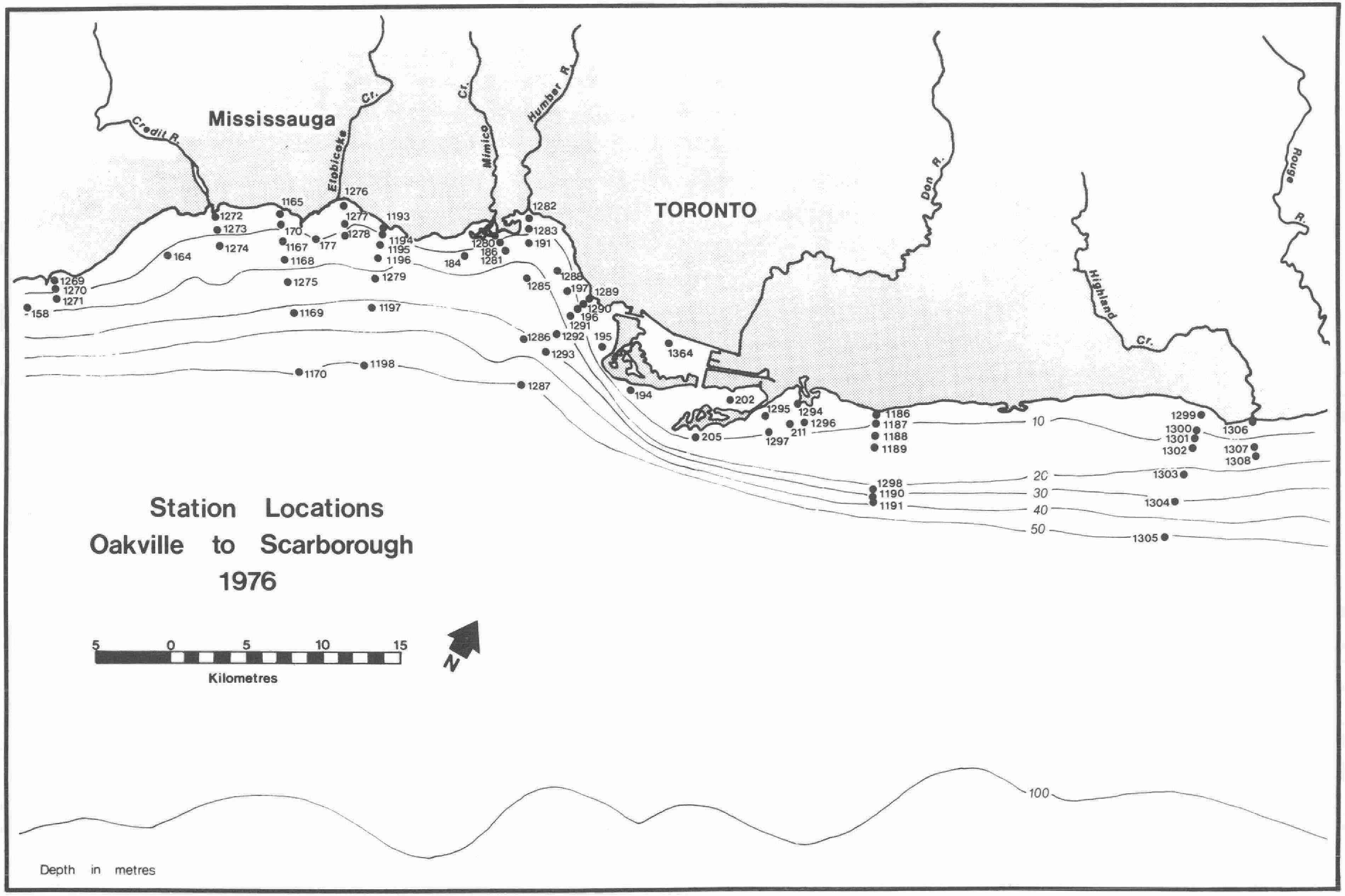
1978



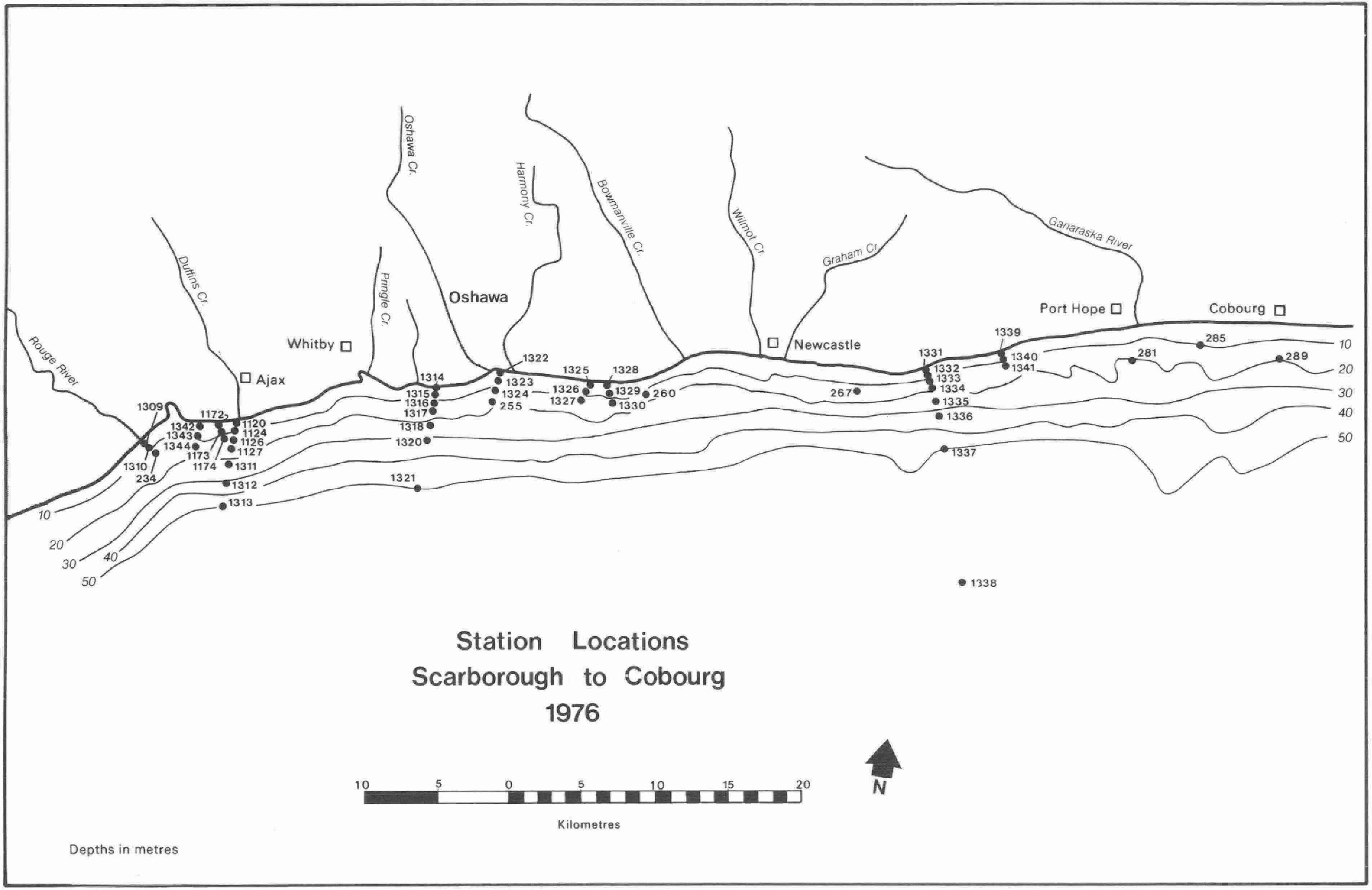
1979

NEARSHORE AREAS OF LAKE ONTARIO SURVEYED IN THE 1976 - 1979 PERIOD

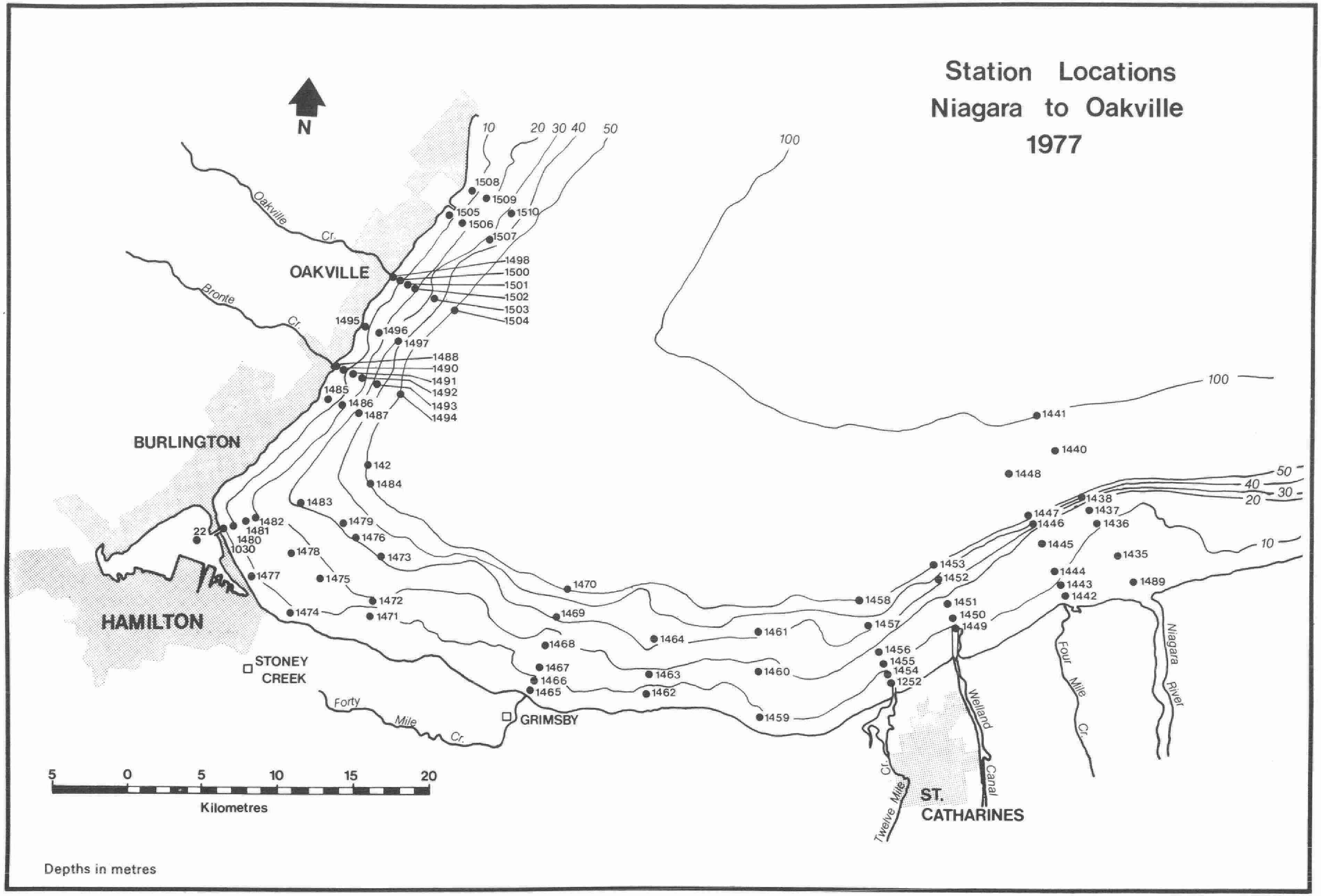

Station Locations
Niagara to Oakville
1976
N
OAKVILLE
BURLINGTON
HAMILTON
STONEY CREEK
GRIMSBY
ST. CATHARINES
Oakville Cr.
Bronte Cr.
Forty Mile Cr.
Twelve Mile Cr.
Welland Canal
Four Mile Cr.
Niagara River
10
20
30
40
50
100
164
1269
1270
1271
158
155
153
1262
1263
1264
1265
1266
1267
1268
150
147
146
142
140
1030
258
132
124
1261
1260
1259
111
1258
1257
1256
1255
1254
1253
1252
1251
1250
1249
1248
1247
69
71
73
60
58
57
75
40
39
2
4
5
0
5
10
15
20
Kilometres
Depths in metres

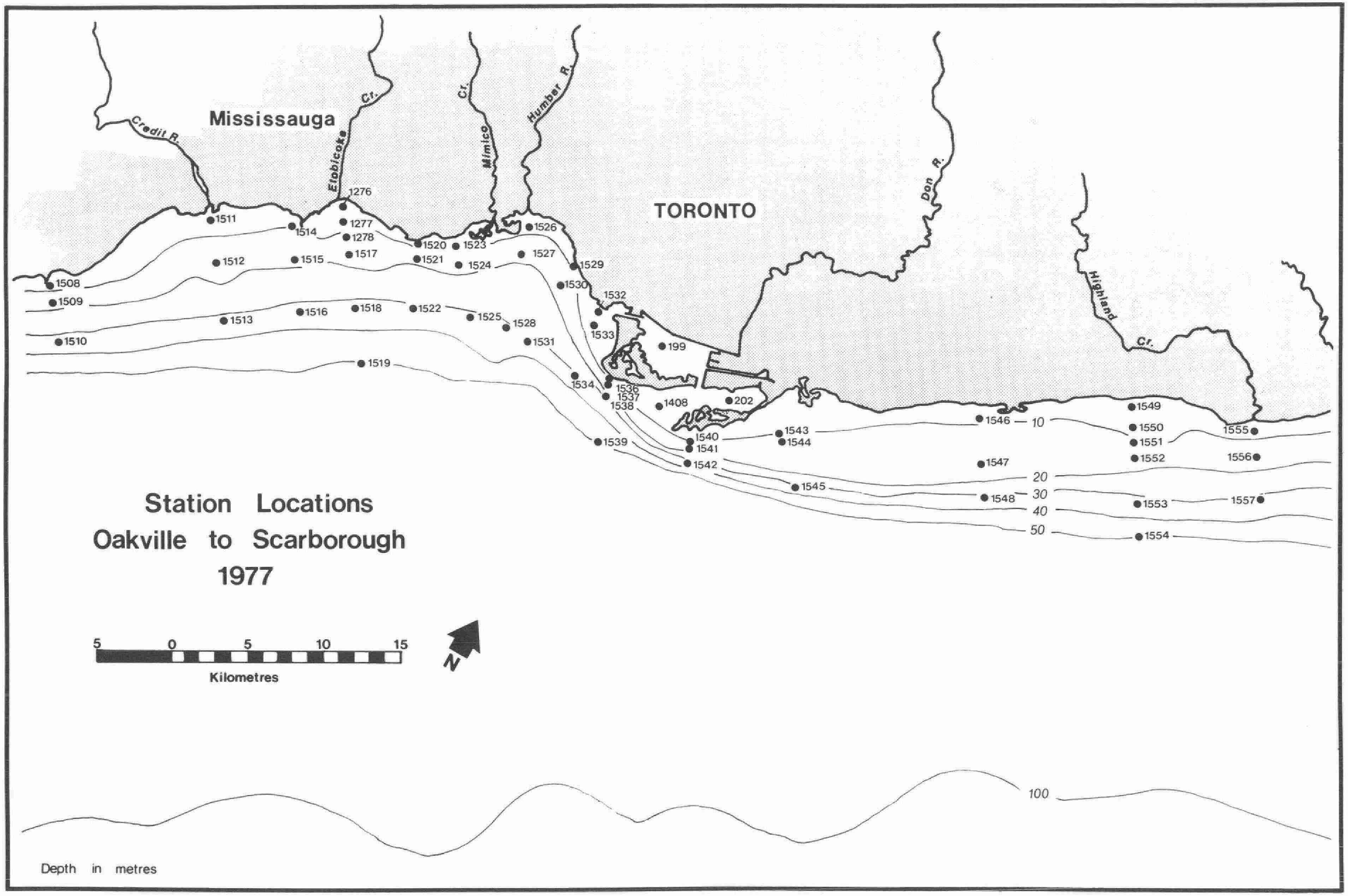


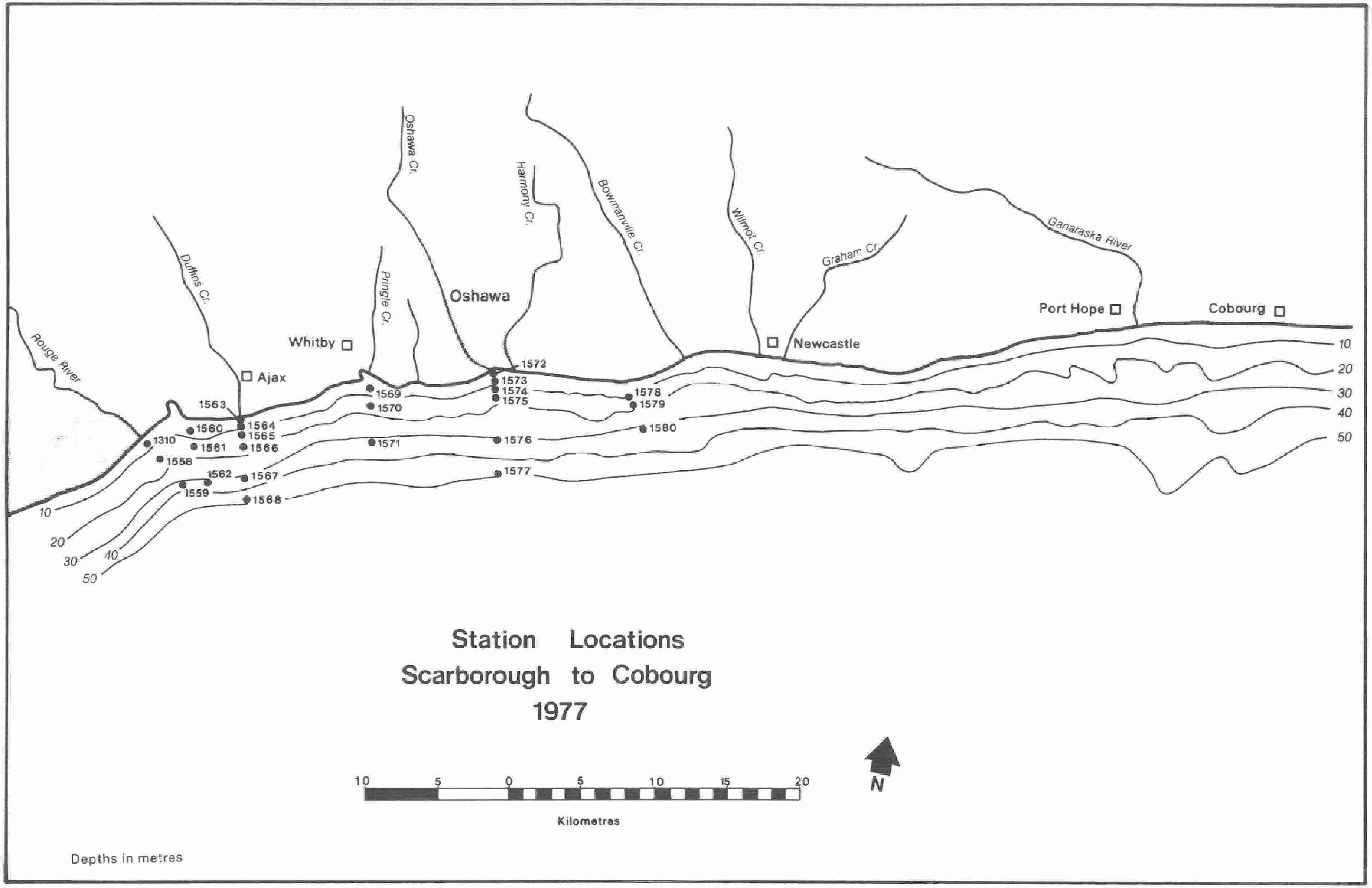
Mississauga
TORONTO
Credit R.
Etobicoke Cr.
Mimico Cr.
Humber R.
Don R.
Highland Cr.
Rouge R.
Station Locations
Oakville to Scarborough
1976
5 0 5 10 15
Kilometres
N
10
20
30
40
50
100
Depth in metres



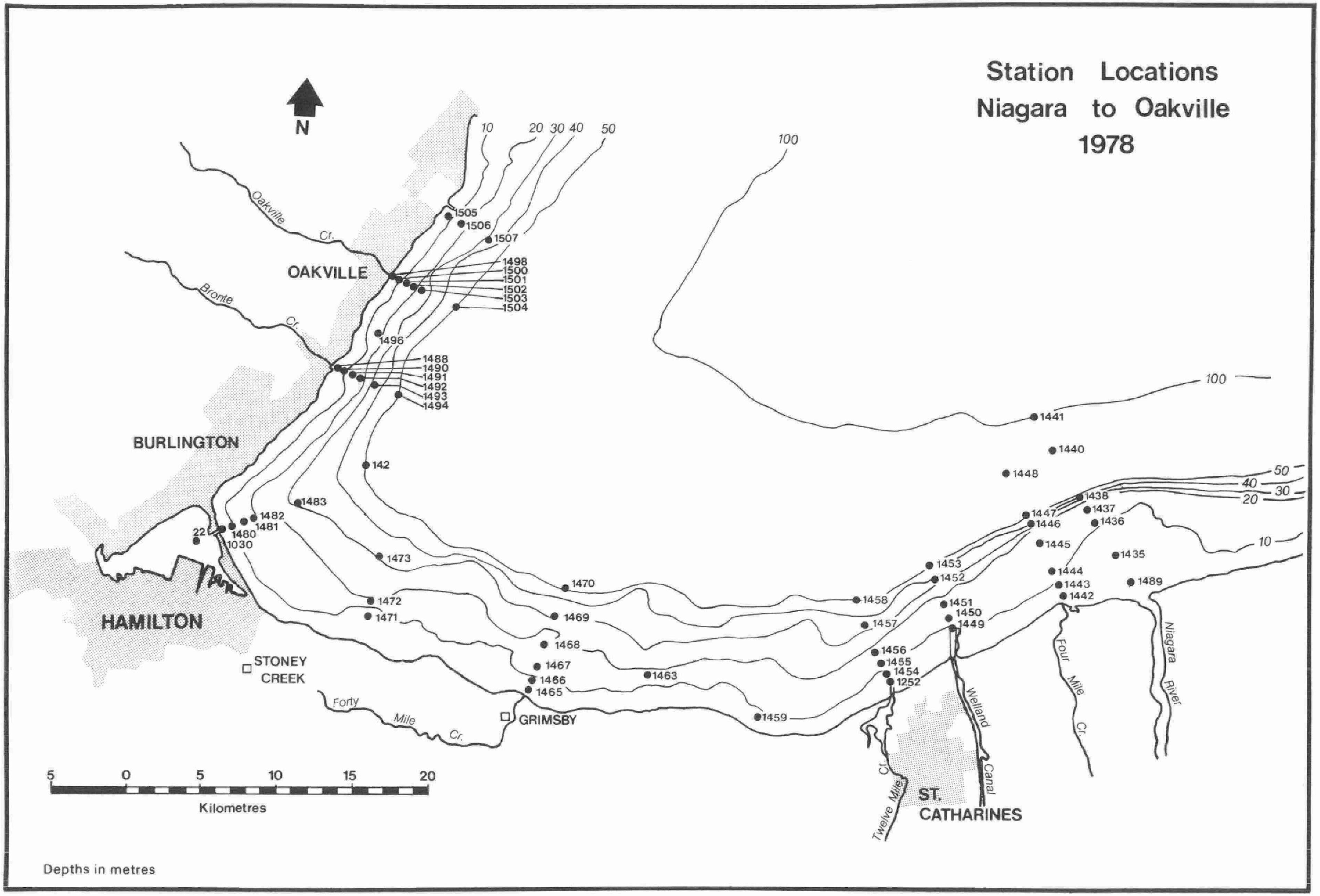
Oshawa
Whitby
Ajax
Newcastle
Port Hope
Cobourg
Rouge River
Duffins Cr.
Pringle Cr.
Oshawa Cr.
Harmony Cr.
Bowmanville Cr.
Wilmot Cr.
Graham Cr.
Ganaraska River
Station Locations
Scarborough to Cobourg
1976
Kilometres
N
Depths in metres

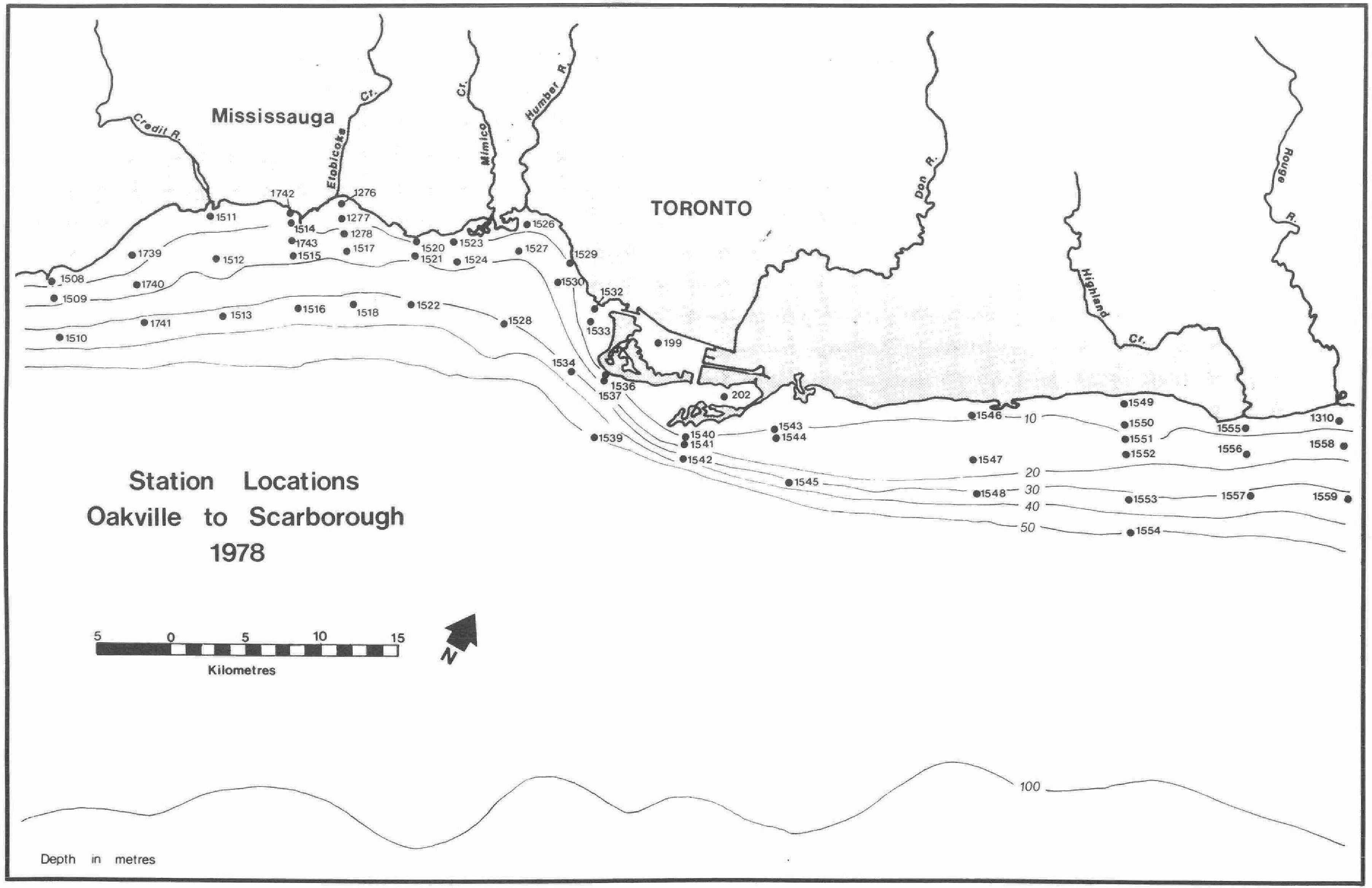

Station Locations
Niagara to Oakville
1977
N
OAKVILLE
BURLINGTON
HAMILTON
STONEY CREEK
GRIMSBY
ST. CATHARINES
Oakville Cr.
Bronte Cr.
Forty Mile Cr.
Twelve Mile Cr.
Welland Canal
Four Mile Cr.
Niagara River
10
20 30 40
50
100
1508
1509
1505
1510
1506
1507
1498
1500
1501
1502
1503
1504
1495
1496
1497
1488
1490
1491
1492
1493
1494
1485
1486
1487
142
1484
1483
1482
1481
1480
1030
22
1479
1476
1478
1473
1477
1475
1472
1474
1471
1470
1469
1468
1467
1466
1465
1464
1463
1462
1461
1460
1459
1458
1457
1456
1455
1454
1252
1453
1452
1451
1450
1449
1447
1446
1445
1444
1443
1442
1438
1437
1436
1435
1489
1448
1441
1440
5 0 5 10 15 20
Kilometres
Depths in metres

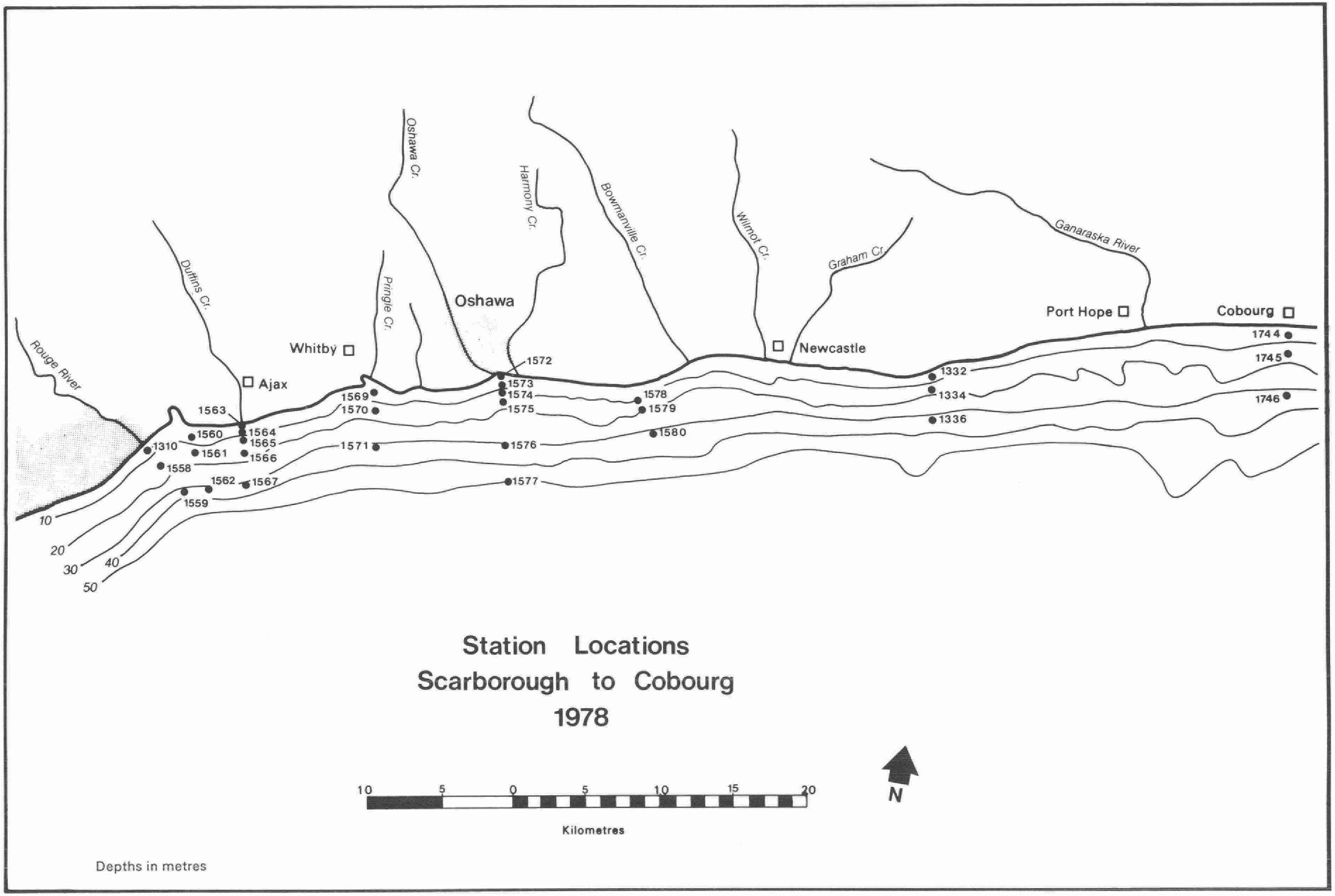

Mississauga
TORONTO
Credit R.
Etobicoke Cr.
Mimico Cr.
Humber R.
Don R.
Highland Cr.
Station Locations
Oakville to Scarborough
1977
Kilometres
N
Depth in metres



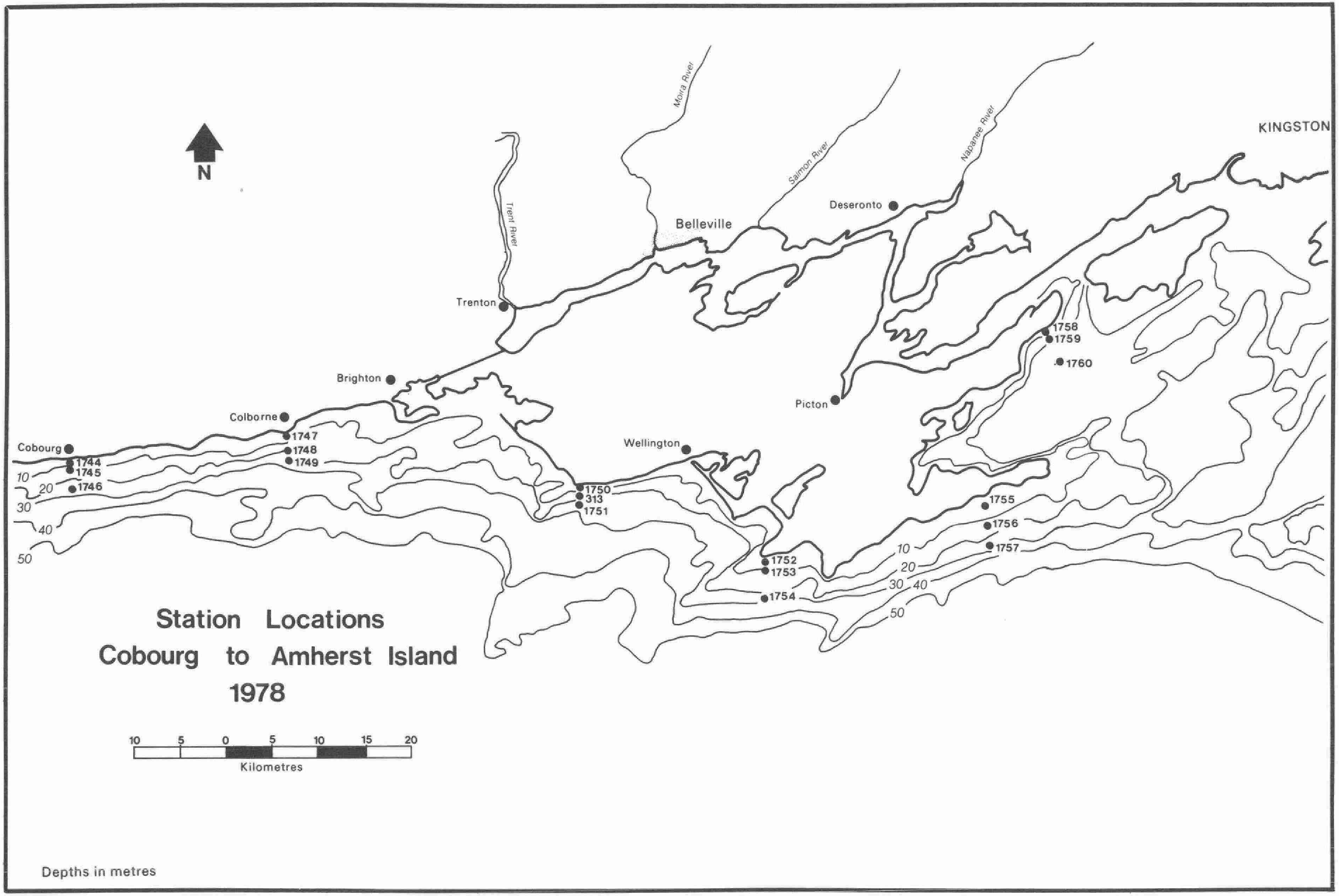
Station Locations
Scarborough to Cobourg
1977


Station Locations
Niagara to Oakville
1978
N
OAKVILLE
BURLINGTON
HAMILTON
STONEY CREEK
GRIMSBY
ST. CATHARINES
Oakville Cr.
Bronte Cr.
Forty Mile Cr.
Twelve Mile Cr.
Welland Canal
Four Mile Cr.
Niagara River
10
20
30
40
50
100
1505
1506
1507
1498
1500
1501
1502
1503
1504
1496
1488
1490
1491
1492
1493
1494
142
1483
1482
1481
1480
1030
22
1473
1472
1471
1470
1469
1468
1467
1466
1465
1463
1459
1458
1457
1456
1455
1454
1252
1453
1452
1451
1450
1449
1441
1440
1448
1438
1437
1436
1447
1446
1445
1435
1444
1443
1442
1489
5 0 5 10 15 20
Kilometres
Depths in metres

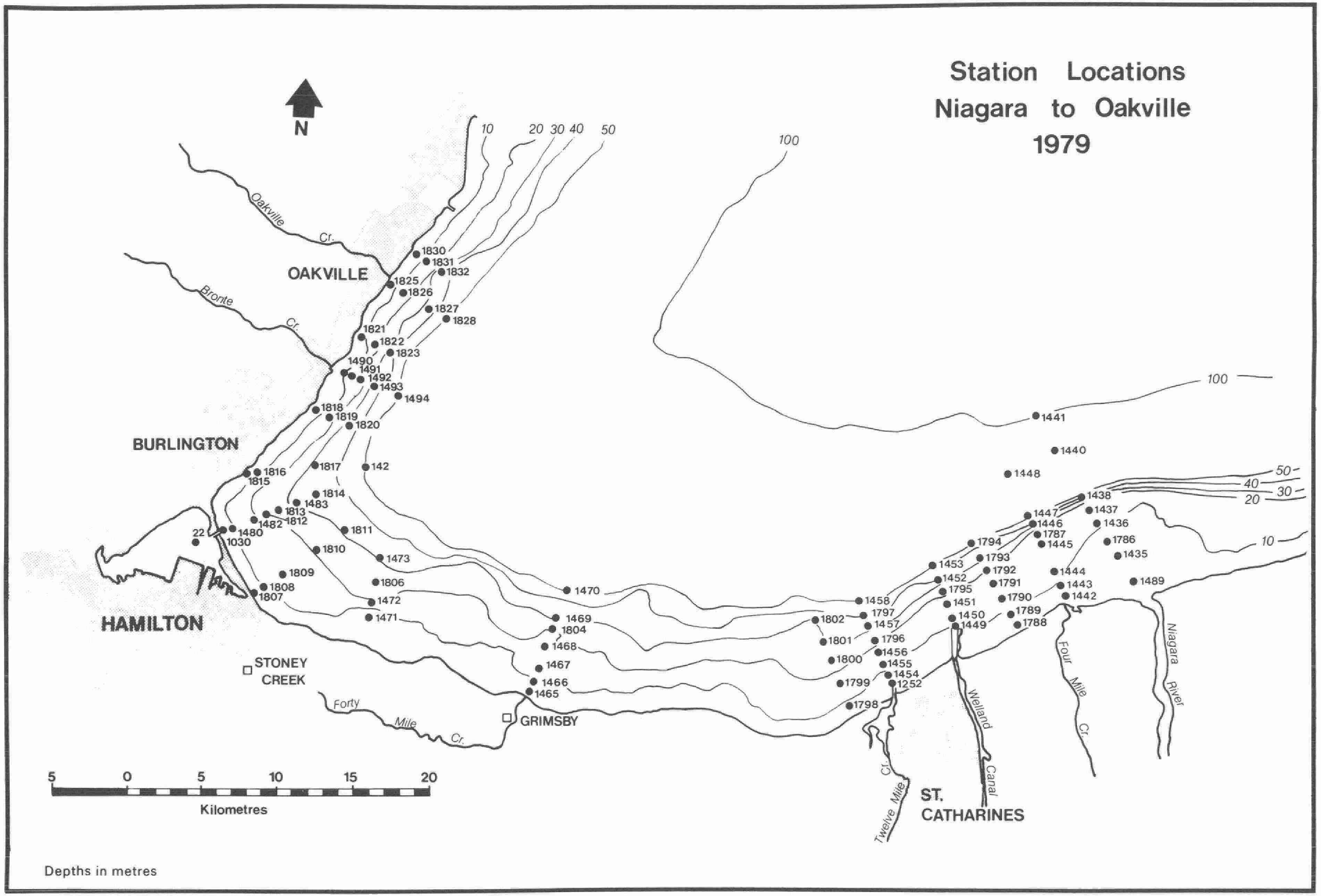

Station Locations
Oakville to Scarborough
1978
Mississauga
TORONTO
Credit R.
Etobicoke Cr.
Mimico Cr.
Humber R.
Don R.
Highland Cr.
Rouge R.
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1520
1521
1522
1523
1524
1526
1527
1528
1529
1530
1532
1533
1534
1536
1537
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1276
1277
1278
1310
1739
1740
1741
1742
1743
199
202
10
20
30
40
50
100
5
0
5
10
15
Kilometres
N
Depth in metres

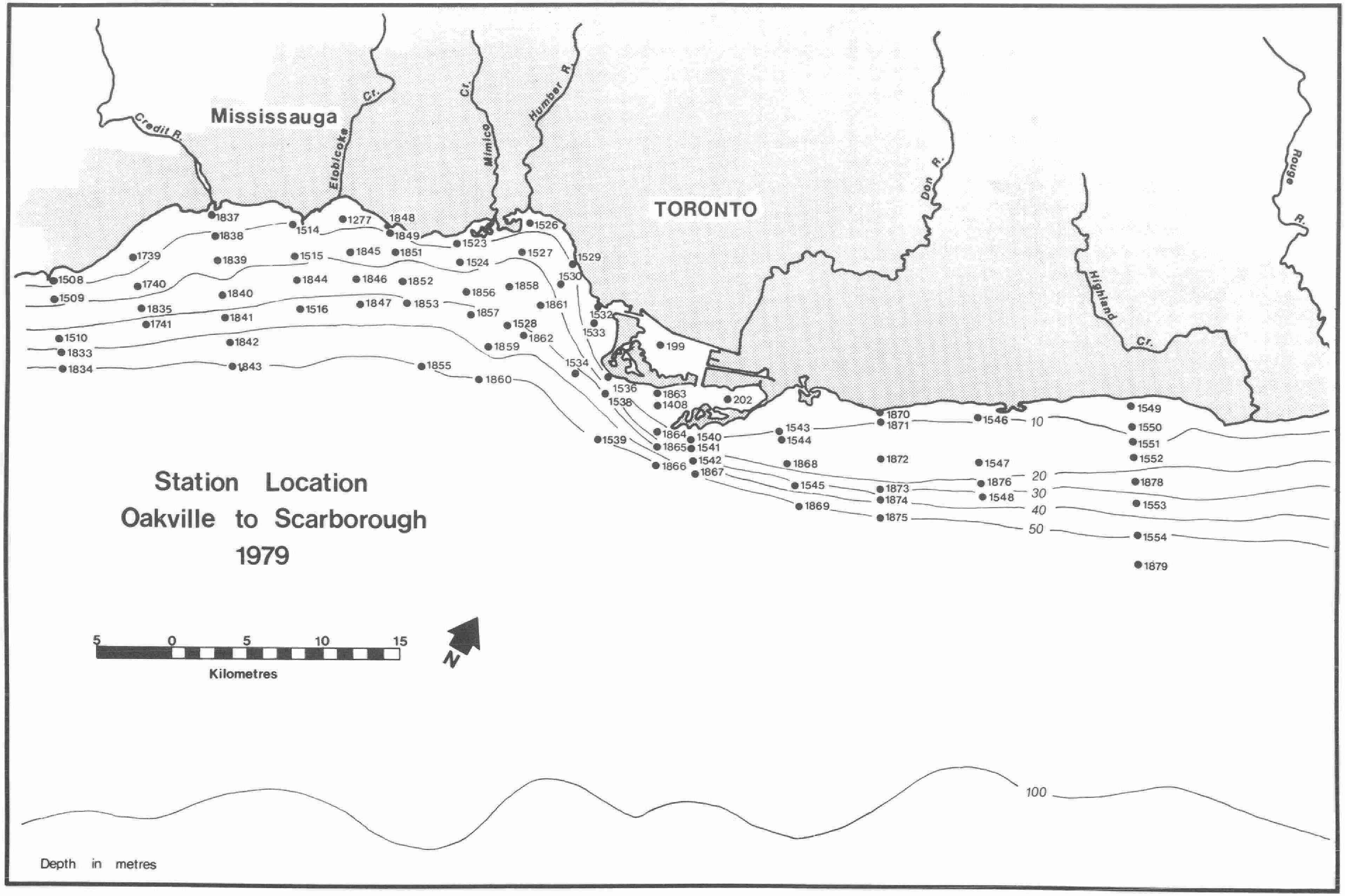


Station Locations
Scarborough to Cobourg
1978



Station Locations
Cobourg to Amherst Island
1978


Station Locations
Niagara to Oakville
1979
N
OAKVILLE
Oakville Cr.
Bronte Cr.
BURLINGTON
HAMILTON
STONEY CREEK
Forty Mile Cr.
GRIMSBY
ST. CATHARINES
Twelve Mile Cr.
Welland Canal
Four Mile Cr.
Niagara River
10
20
30
40
50
100
5
0
5
10
15
20
Kilometres
Depths in metres


Mississauga
TORONTO
Credit R.
Etobicoke Cr.
Mimico Cr.
Humber R.
Don R.
Highland Cr.
Rouge R.
Station Location
Oakville to Scarborough
1979
Kilometres
5 0 5 10 15
N
Depth in metres
10
20
30
40
50
100
1508
1509
1510
1833
1834
1739
1740
1835
1741
1837
1838
1839
1840
1841
1842
1843
1514
1515
1844
1516
1277
1845
1846
1847
1848
1849
1851
1852
1853
1855
1523
1524
1856
1857
1859
1860
1526
1527
1858
1528
1862
1861
1529
1530
1532
1533
1534
1536
1538
1539
199
1863
1408
202
1864
1865
1866
1540
1541
1542
1867
1543
1544
1868
1545
1869
1870
1871
1872
1873
1874
1875
1546
1547
1876
1548
1549
1550
1551
1552
1878
1553
1554
1879

WATER QUALITY VARIABLES SAMPLED BY THE
MINISTRY OF THE ENVIRONMENT IN NEARSHORE AREAS OF LAKE ONTARIO
DURING 1976-1979 SURVEY PERIODS

	YEAR					YEAR			
	1976	1977	1978	1979		1976	1977	1978	1979
Alkalinity	x	x	x	*	Nitrogen, Total Kjeldahl	x	x	x	x
Bacteria, Heterotrophic	x	*	*	*	Oxygen, Dissolved	x	x	x	x
Bacteria, Fecal Coliforms	x	*	*	*	Phenols	*	*	*	o
Bacteria, Streptococci	x	*	*	*	pH	x	x	x	x
Bacteria, Total Coliforms	x	*	*	o	Phosphorus, Total	x	x	x	x
Bacteria, Pseudomonas	x	*	*	*	Phosphorus, Reactive	x	x	x	o
Calcium	*	*	*	*	Phosphorus, Total Filtered	o	x	x	x
Carbon, Inorganic, Organic	*	*	*	*	Potassium	*	*	*	*
Chloride	x	x	*	*	Secchi Disk Depth	x	x	x	x
Chlorophyll <u>a</u>	x	o	x	x	Silicate, Reactive	x	x	x	x
Chlorophyll <u>a</u> (corrected)	x	o	x	x	Sodium	*	*	*	*
Chlorophyll <u>b</u>	x	o	x	x	Solids, Total	*	*	*	*
Conductivity	x	x	x	x	Solids, Dissolved	*	*	*	*
Fluoride	*	*	*	*	Solids, Suspended	*	*	*	*
Iron, Total	*	*	*	*	Sulphate	*	*	*	*
Magnesium	*	*	*	*	Temperature	x	x	x	x
Nitrogen, Ammonia	x	x	x	x	Turbidity	x	x	x	x
Nitrogen, Nitrite + Nitrate	x	x	x	x	Water Depths	x	x	x	x

x All Stations
o Not Sampled
* Selected Stations Only

SAMPLING DATES FOR 1976-1979 SURVEY PERIODS

1976

RUN 1	RUN 2	RUN 3
Niagara River to Stoney Creek April 6	Stoney Creek to Niagara River April 7	Niagara River to Stoney Creek April 9
Hamilton to Etobicoke Creek April 10	Etobicoke Creek to Hamilton April 12	Hamilton to Etobicoke Creek April 13
Etobicoke Creek to Ashbridges Bay April 14	Ashbridges Bay to Etobicoke Creek April 16	Etobicoke Creek to Ashbridges Bay April 17
Scarborough to Whitby April 18	Whitby to Scarborough April 19	Scarborough to Whitby April 20
Coburg to Whitby April 24	Whitby to Coburg April 28	Coburg to Whitby April 29

1977

RUN 1	RUN 2	RUN 3
Niagara River to Grimbsy April 10-12	Grimbsy to Niagara River April 13	Niagara River to Grimbsy April 14
Grimbsy to Credit River April 15	Credit River to Grimbsy April 16	Grimbsy to Credit River April 17
Credit River to Ashbridges Bay April 19	Ashbridges Bay to Credit River April 20	Credit River to Ashbridges Bay April 21
Scarborough to Oshawa April 23	Oshawa to Scarborough April 24	Scarborough to Oshawa April 25

SAMPLING DATES FOR 1976-1979 SURVEY PERIODS (continued)

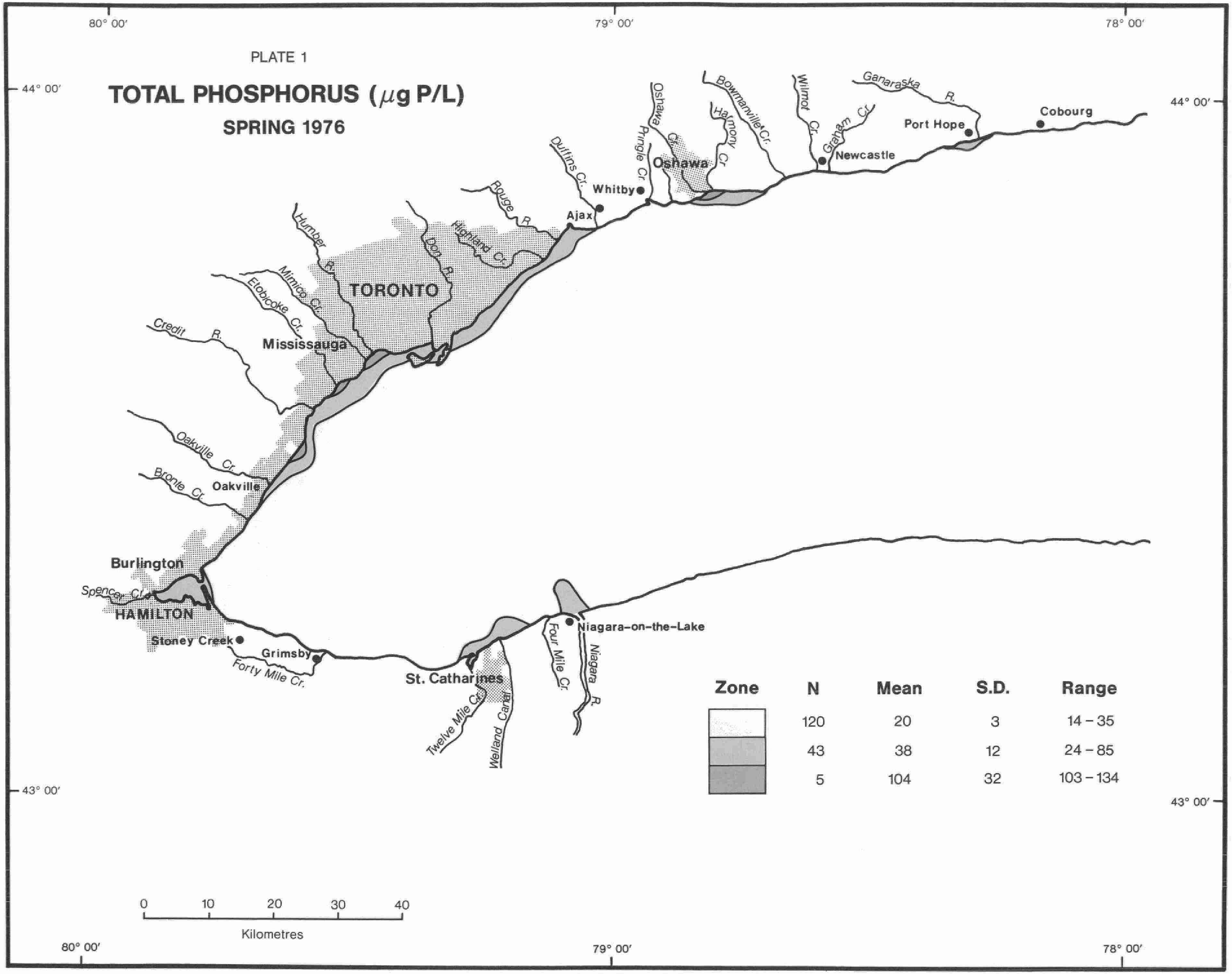
1978

RUN 1	RUN 2	RUN 3
Niagara River to Stoney Creek April 13-16	Stoney Creek to Niagara River April 17	Niagara River to Stoney Creek April 22
Hamilton to Credit River April 23	Credit River to Hamilton April 24	Hamilton to Credit River April 25
Lakeview to Ashbridges Bay April 26	Ashbridges Bay to Lakeview April 27	Lakeview to Ashbridges Bay April 28-30
Scarborough to Oshawa May 2	Oshawa to Scarborough May 3	Scarborough to Oshawa May 7
Bowmanville to Colborne May 9	Colborne to Bowmanville May 10	Bowmanville to Colborne May 1
Scotch Bonnet Is. to Amherst Is. May 17	Amherst Is. to Scotch Bonnet Is. May 18	Scotch Bonnet Is. to Amherst Is. May 19

1979

RUN 1	RUN 2	RUN 3
Highland Cr. to Ontario Place April 19	Ontario Place to Highland Cr. April 28	Highland Cr. to Ontario Place April 29
Ontario Place to Clarkson April 20	Clarkson to Ontario Place April 27	Ontario Place to Clarkson April 30
Port Credit to Burlington April 21	Burlington to Port Credit April 26	Port Credit to Burlington May 1
Hamilton to Niagara River April 22-23	Niagara River to Hamilton April 24-25	Hamilton to Niagara River May 2-3

APPENDIX C

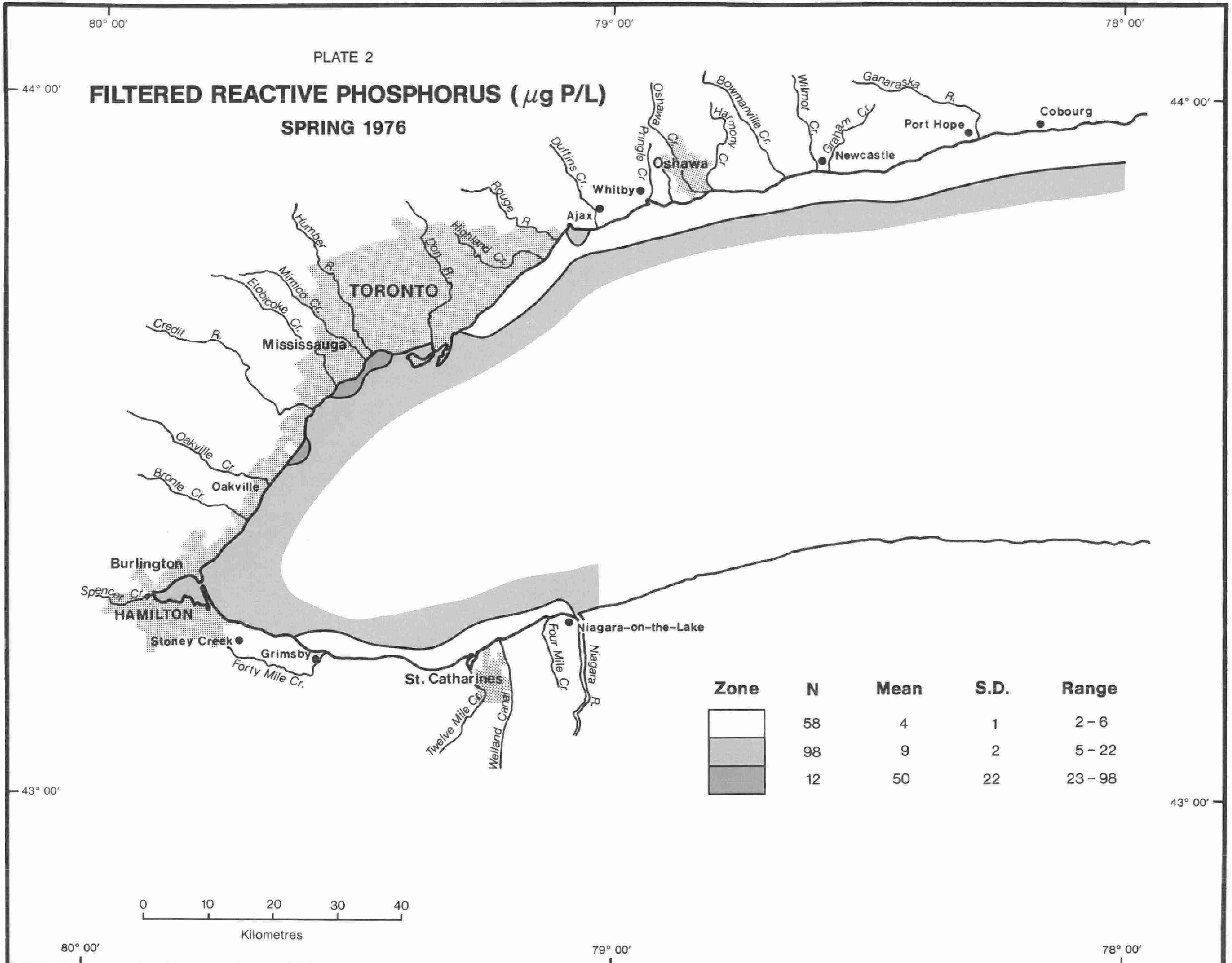


Zone	N	Mean	S.D.	Range
	120	20	3	14 – 35
	43	38	12	24 – 85
	5	104	32	103 – 134

PLATE 2

FILTERED REACTIVE PHOSPHORUS (μg P/L)

SPRING 1976

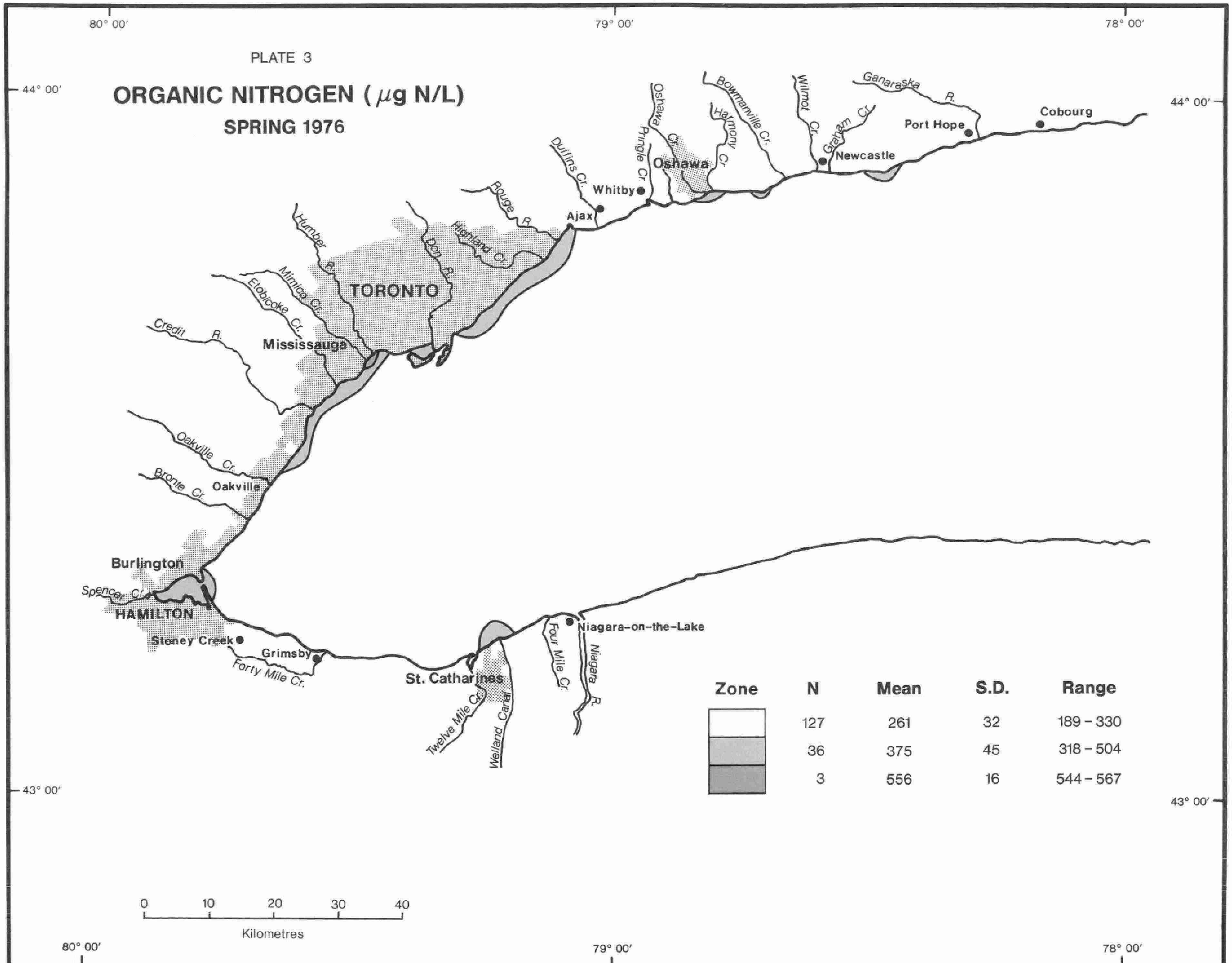


Zone	N	Mean	S.D.	Range
(white)	58	4	1	2 - 6
(light grey)	98	9	2	5 - 22
(dark grey)	12	50	22	23 - 98

PLATE 3

ORGANIC NITROGEN (μg N/L)

SPRING 1976

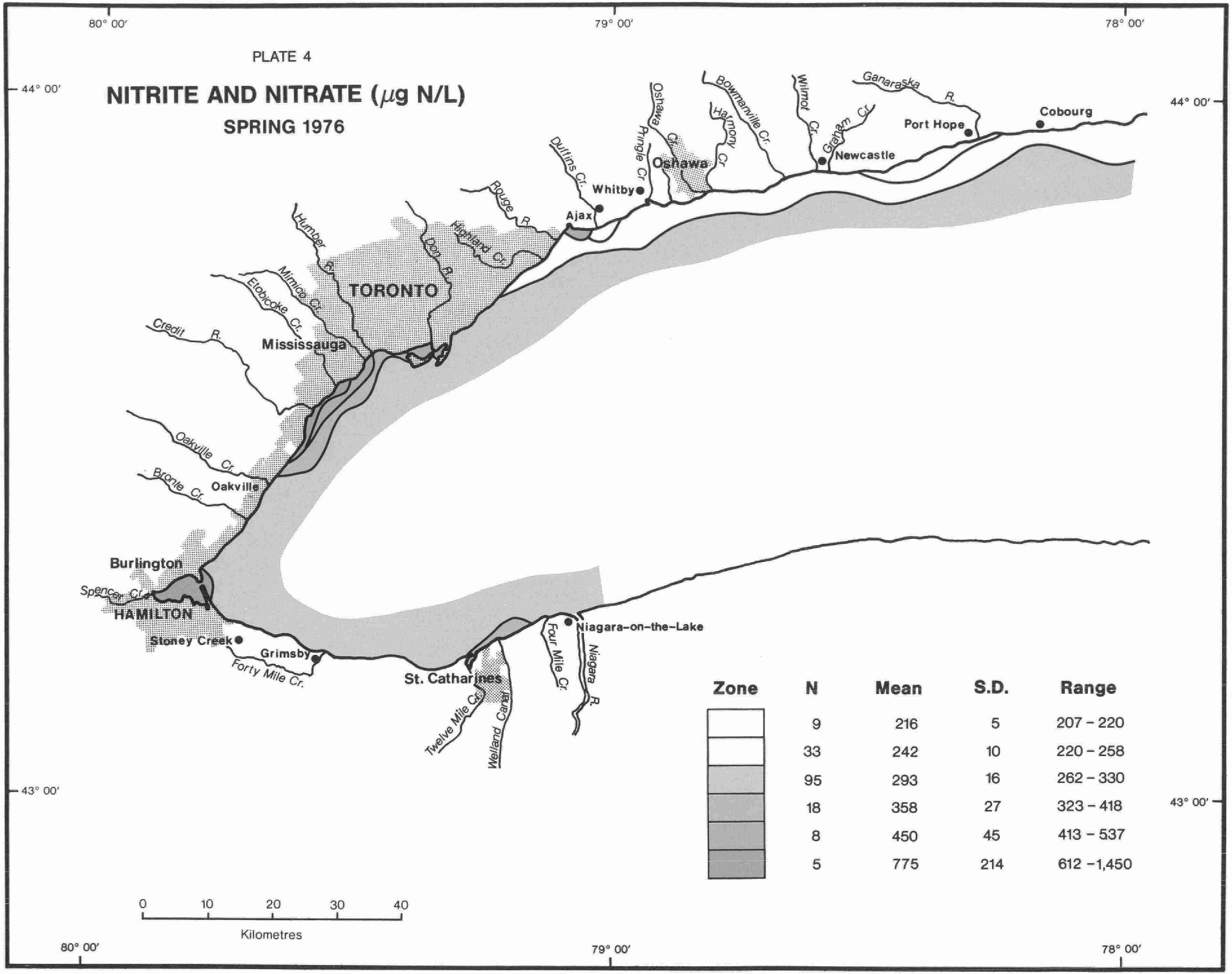


Zone	N	Mean	S.D.	Range
(white)	127	261	32	189 – 330
(light shading)	36	375	45	318 – 504
(dark shading)	3	556	16	544 – 567

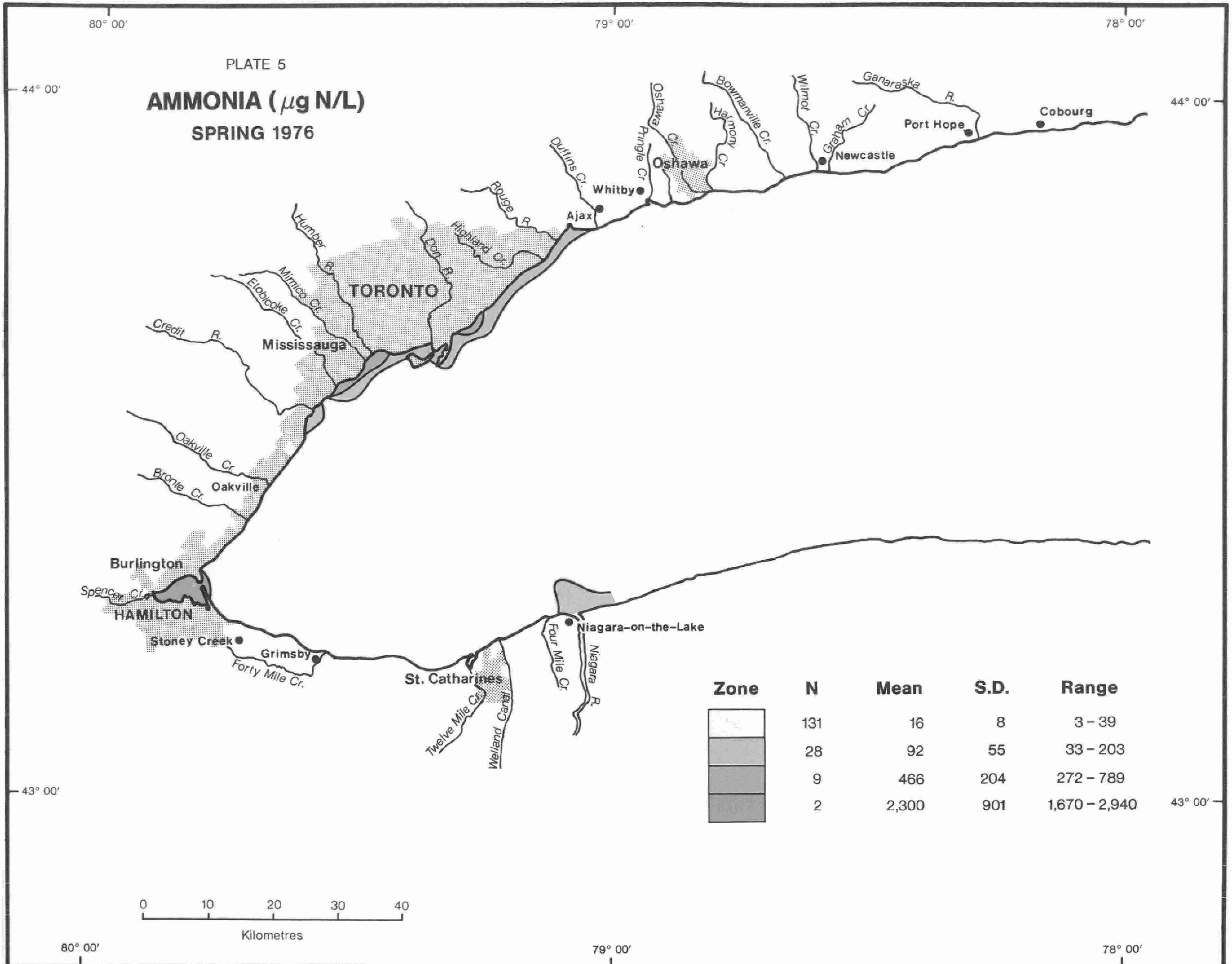
PLATE 4

NITRITE AND NITRATE (μg N/L)

SPRING 1976



Zone	N	Mean	S.D.	Range
	9	216	5	207 - 220
	33	242	10	220 - 258
	95	293	16	262 - 330
	18	358	27	323 - 418
	8	450	45	413 - 537
	5	775	214	612 -1,450



Zone	N	Mean	S.D.	Range
(white)	131	16	8	3 – 39
(light)	28	92	55	33 – 203
(medium)	9	466	204	272 – 789
(dark)	2	2,300	901	1,670 – 2,940

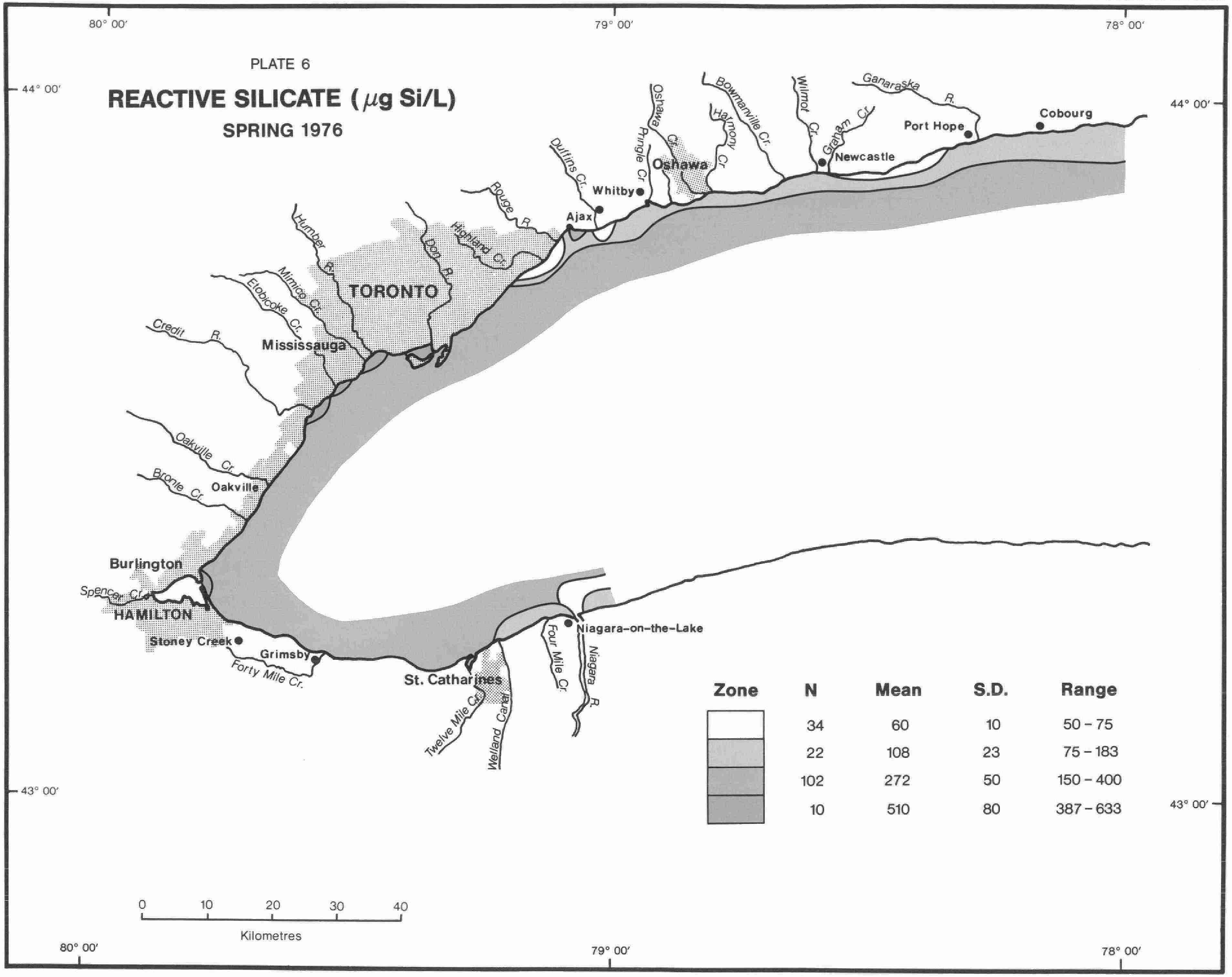
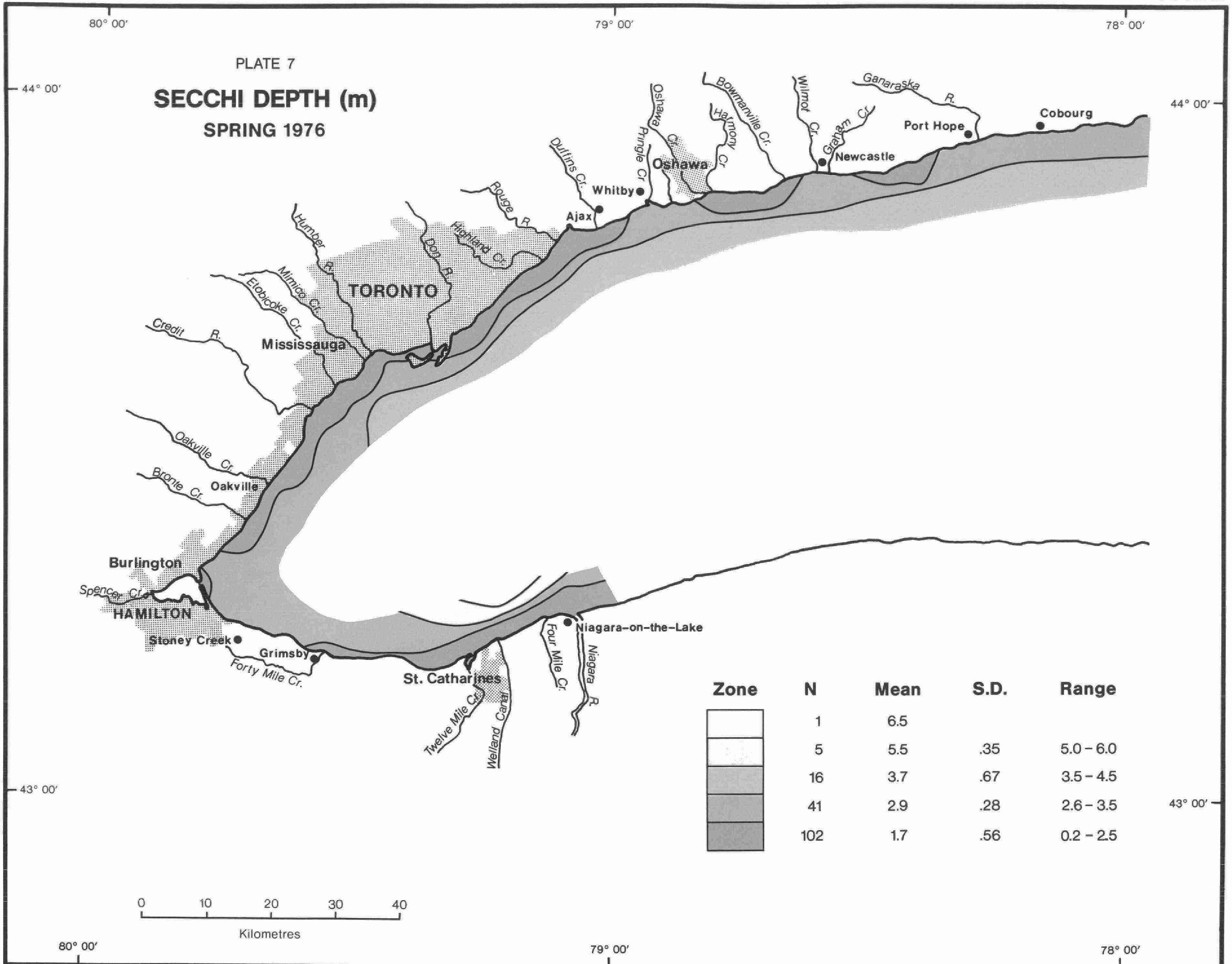


PLATE 6
REACTIVE SILICATE (μg Si/L)
SPRING 1976
80° 00′
79° 00′
78° 00′
44° 00′
43° 00′
TORONTO
Mississauga
Oakville
Burlington
HAMILTON
Stoney Creek
Grimsby
St. Catharines
Niagara-on-the-Lake
Ajax
Whitby
Oshawa
Newcastle
Port Hope
Cobourg
Credit R.
Etobicoke Cr.
Mimico Cr.
Humber R.
Don R.
Highland Cr.
Rouge R.
Duffins Cr.
Pringle Cr.
Oshawa Cr.
Harmony Cr.
Bowmanville Cr.
Wilmot Cr.
Graham Cr.
Ganaraska R.
Oakville Cr.
Bronte Cr.
Spencer Cr.
Forty Mile Cr.
Twelve Mile Cr.
Welland Canal
Four Mile Cr.
Niagara R.
Zone N Mean S.D. Range
34 60 10 50 - 75
22 108 23 75 - 183
102 272 50 150 - 400
10 510 80 387 - 633
0 10 20 30 40
Kilometres

PLATE 7

SECCHI DEPTH (m)

SPRING 1976

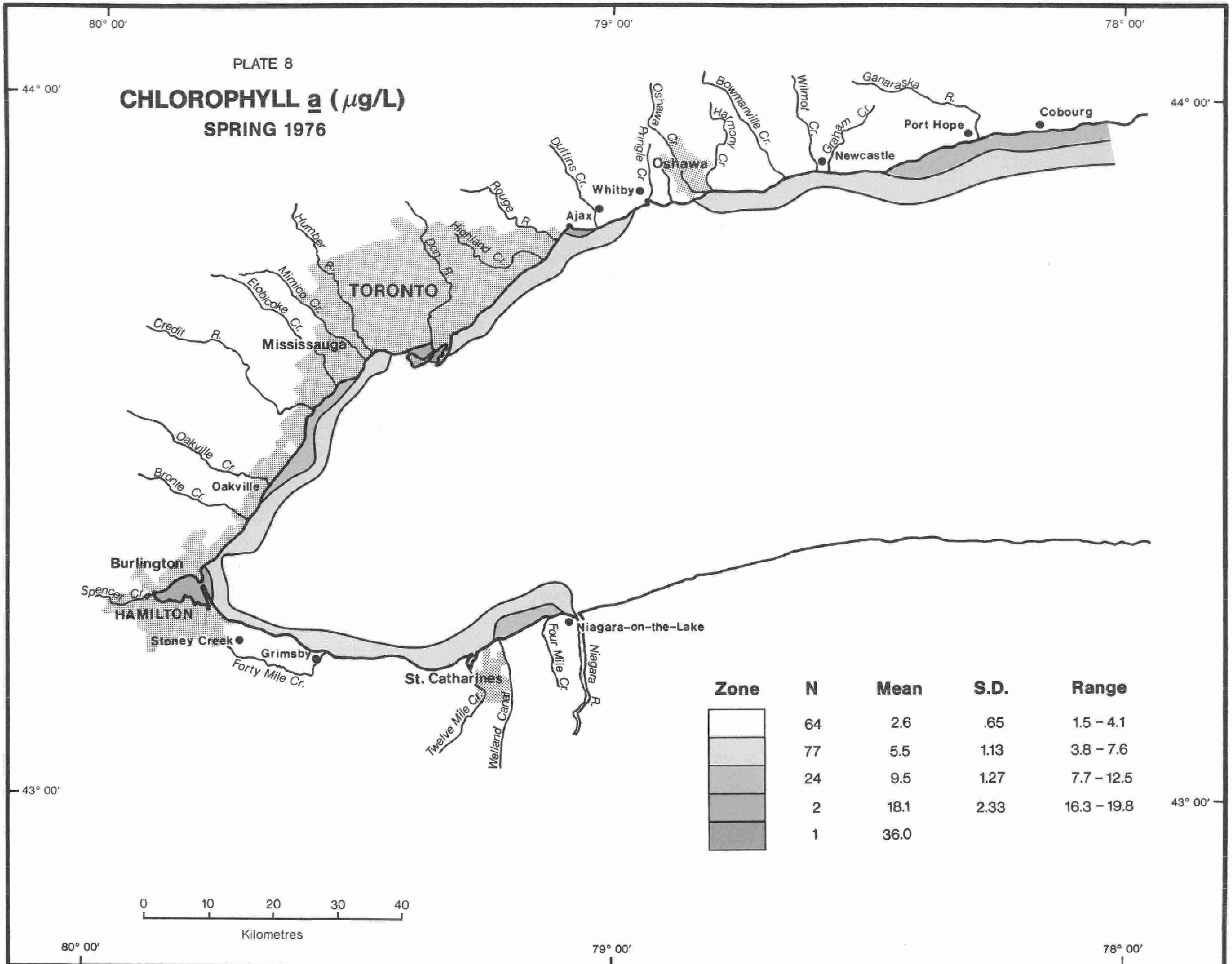


Zone	N	Mean	S.D.	Range
	1	6.5		
	5	5.5	.35	5.0 - 6.0
	16	3.7	.67	3.5 - 4.5
	41	2.9	.28	2.6 - 3.5
	102	1.7	.56	0.2 - 2.5

PLATE 8

CHLOROPHYLL a (μg/L)

SPRING 1976



Zone	N	Mean	S.D.	Range
	64	2.6	.65	1.5 - 4.1
	77	5.5	1.13	3.8 - 7.6
	24	9.5	1.27	7.7 - 12.5
	2	18.1	2.33	16.3 - 19.8
	1	36.0		

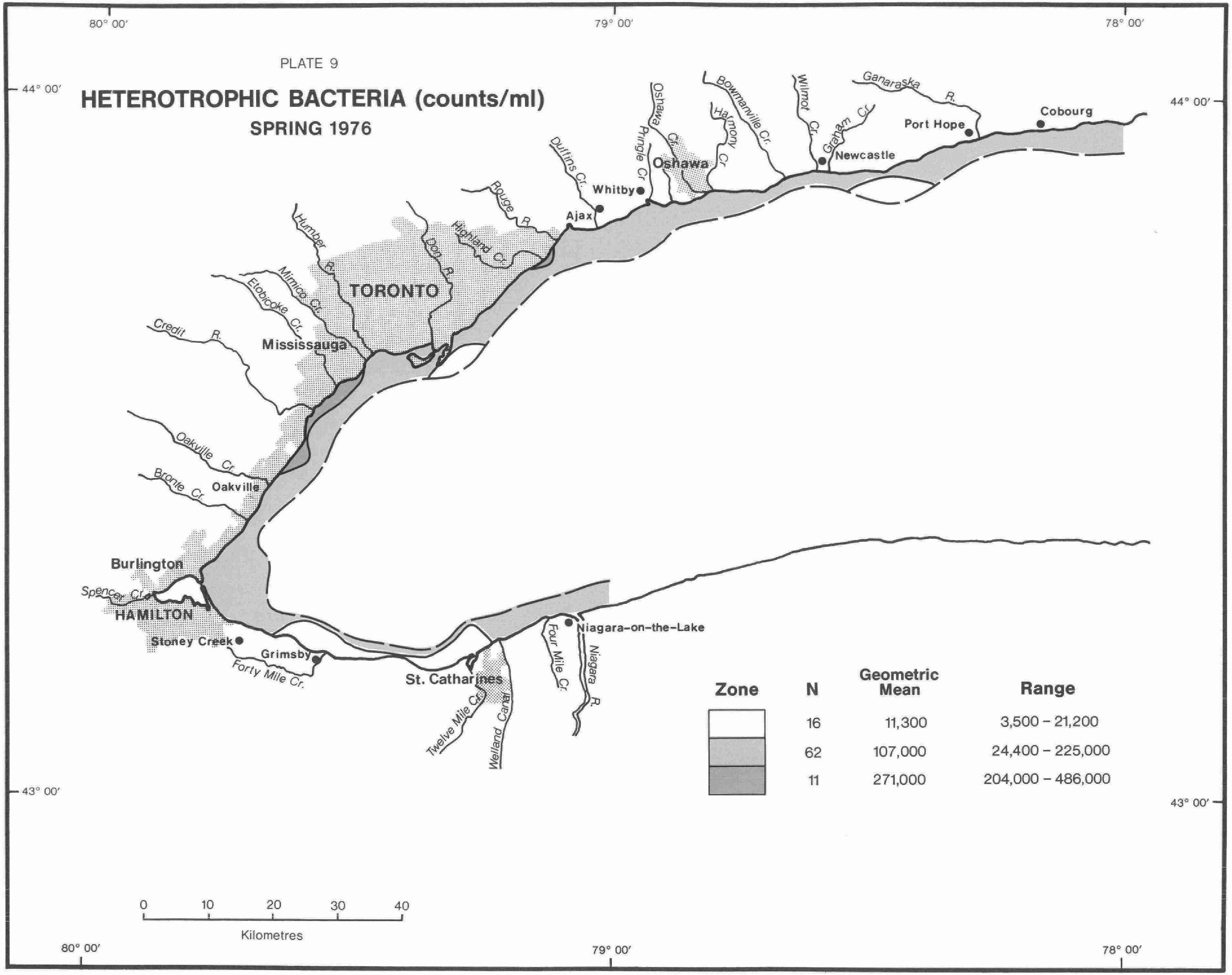
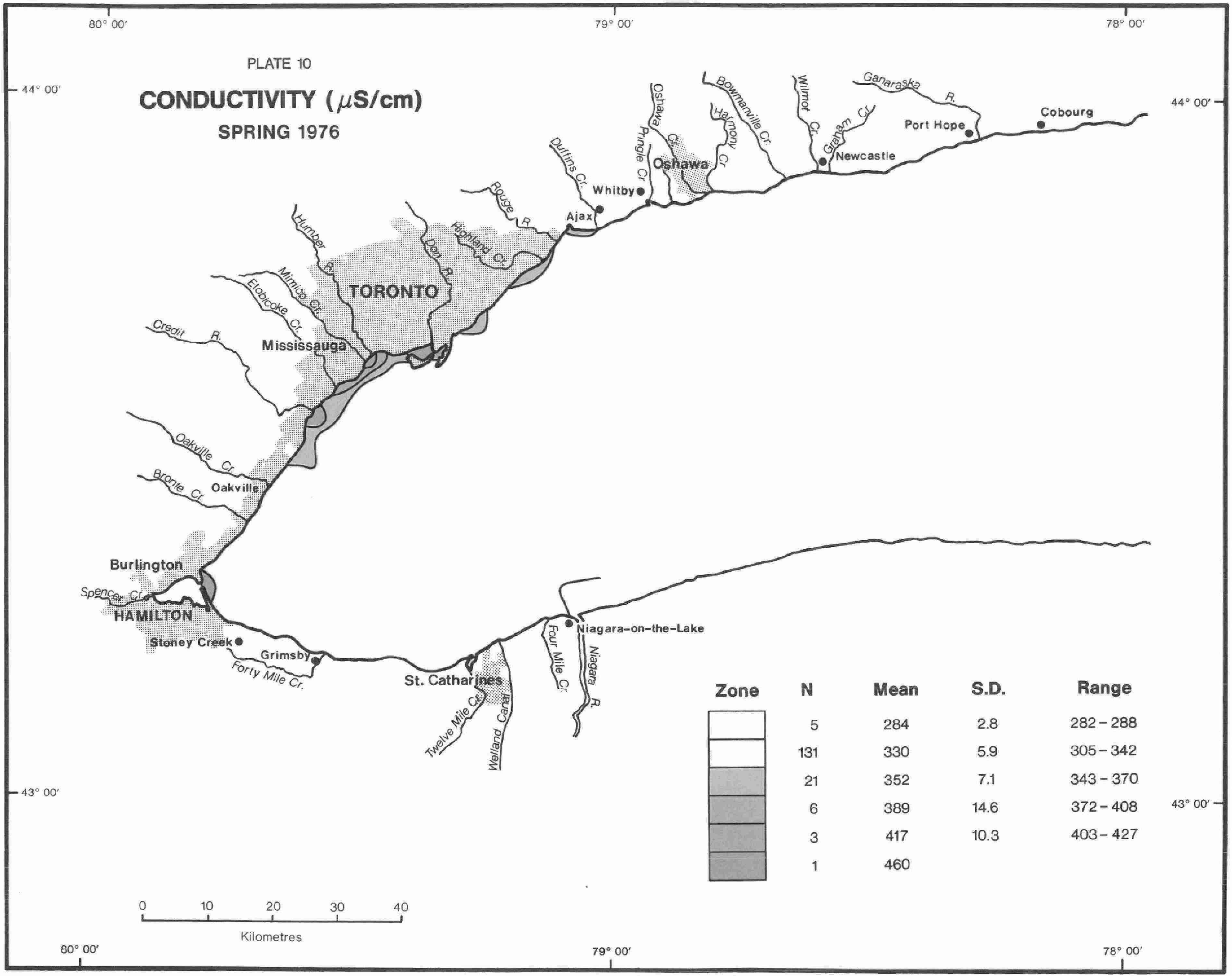


PLATE 9
HETEROTROPHIC BACTERIA (counts/ml)
SPRING 1976
80° 00′
79° 00′
78° 00′
44° 00′
43° 00′
Oshawa Cr.
Bowmanville Cr.
Wilmot Cr.
Ganaraska R.
Harmony Cr.
Graham Cr.
Port Hope
Cobourg
Duffins Cr.
Pringle Cr.
Oshawa
Newcastle
Whitby
Rouge R.
Ajax
Humber R.
Highland Cr.
Don R.
Mimico Cr.
Etobicoke Cr.
TORONTO
Credit R.
Mississauga
Oakville Cr.
Bronte Cr.
Oakville
Burlington
Spencer Cr.
HAMILTON
Stoney Creek
Grimsby
Forty Mile Cr.
St. Catharines
Twelve Mile Cr.
Welland Canal
Four Mile Cr.
Niagara-on-the-Lake
Niagara R.
Zone
N
Geometric Mean
Range
16
11,300
3,500 – 21,200
62
107,000
24,400 – 225,000
11
271,000
204,000 – 486,000
0
10
20
30
40
Kilometres

PLATE 10

CONDUCTIVITY (μS/cm)

SPRING 1976



Zone	N	Mean	S.D.	Range
	5	284	2.8	282 - 288
	131	330	5.9	305 - 342
	21	352	7.1	343 - 370
	6	389	14.6	372 - 408
	3	417	10.3	403 - 427
	1	460		

PLATE 11

TEMPERATURE (°C)

SPRING 1976

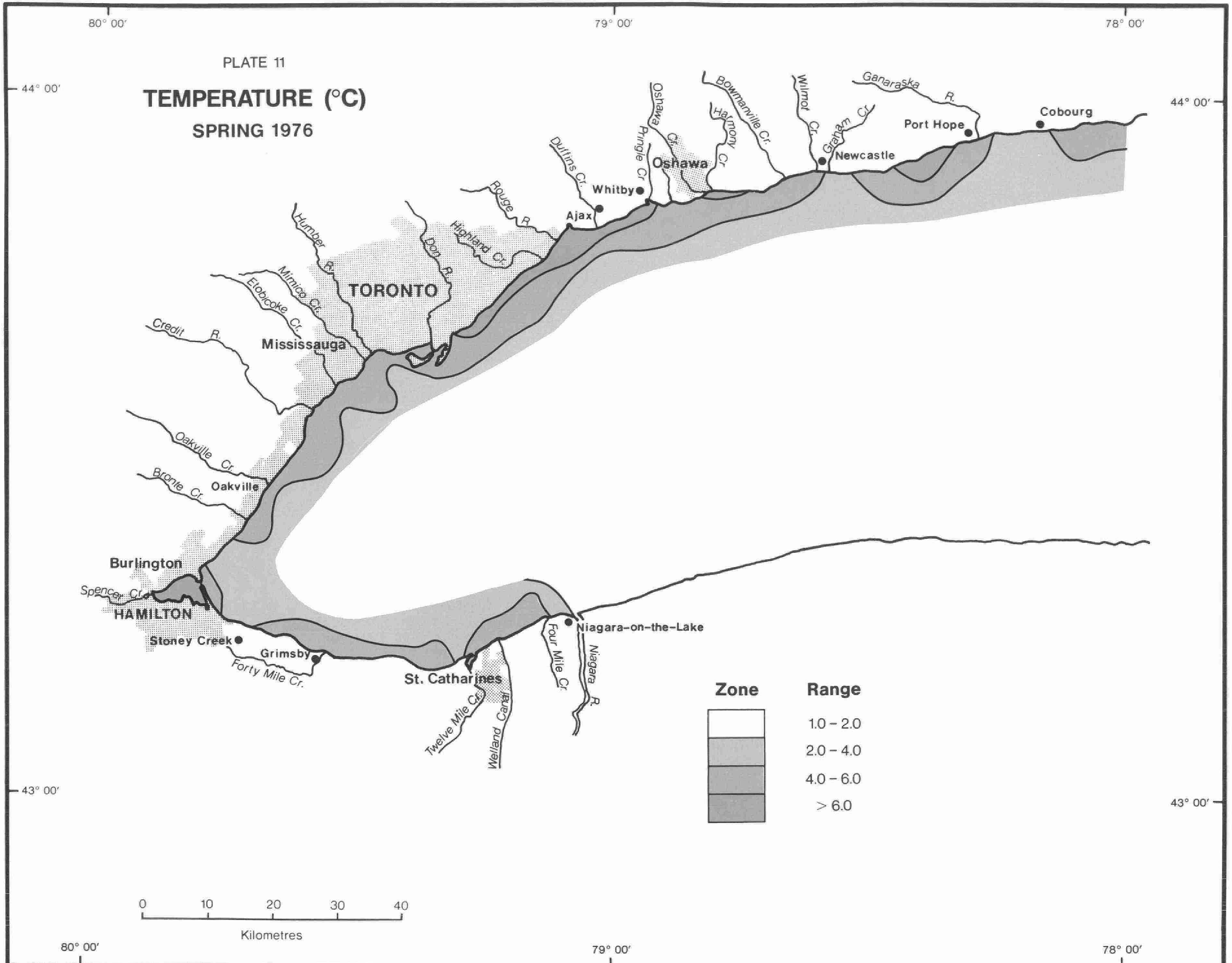
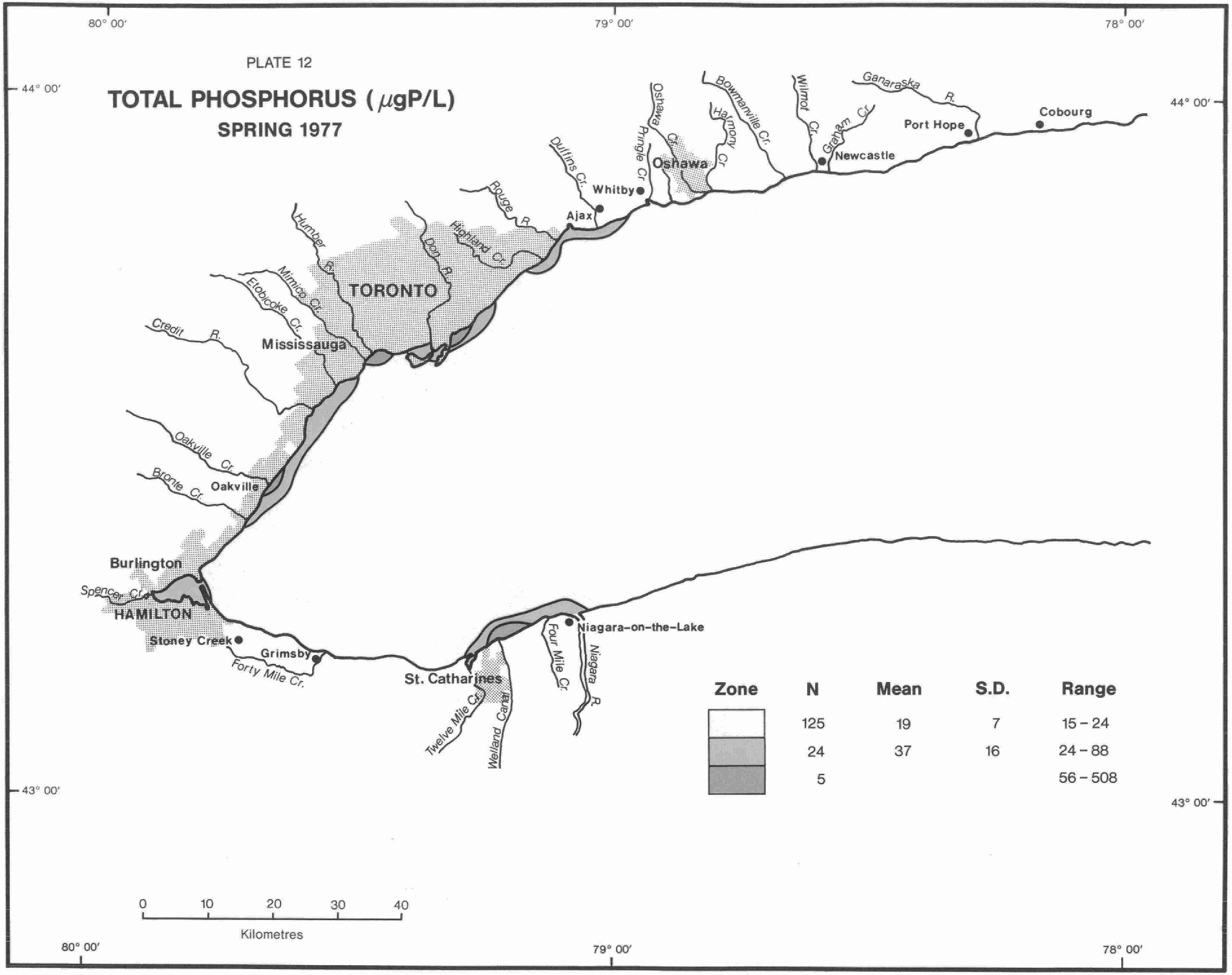


PLATE 12

TOTAL PHOSPHORUS (μgP/L)
SPRING 1977

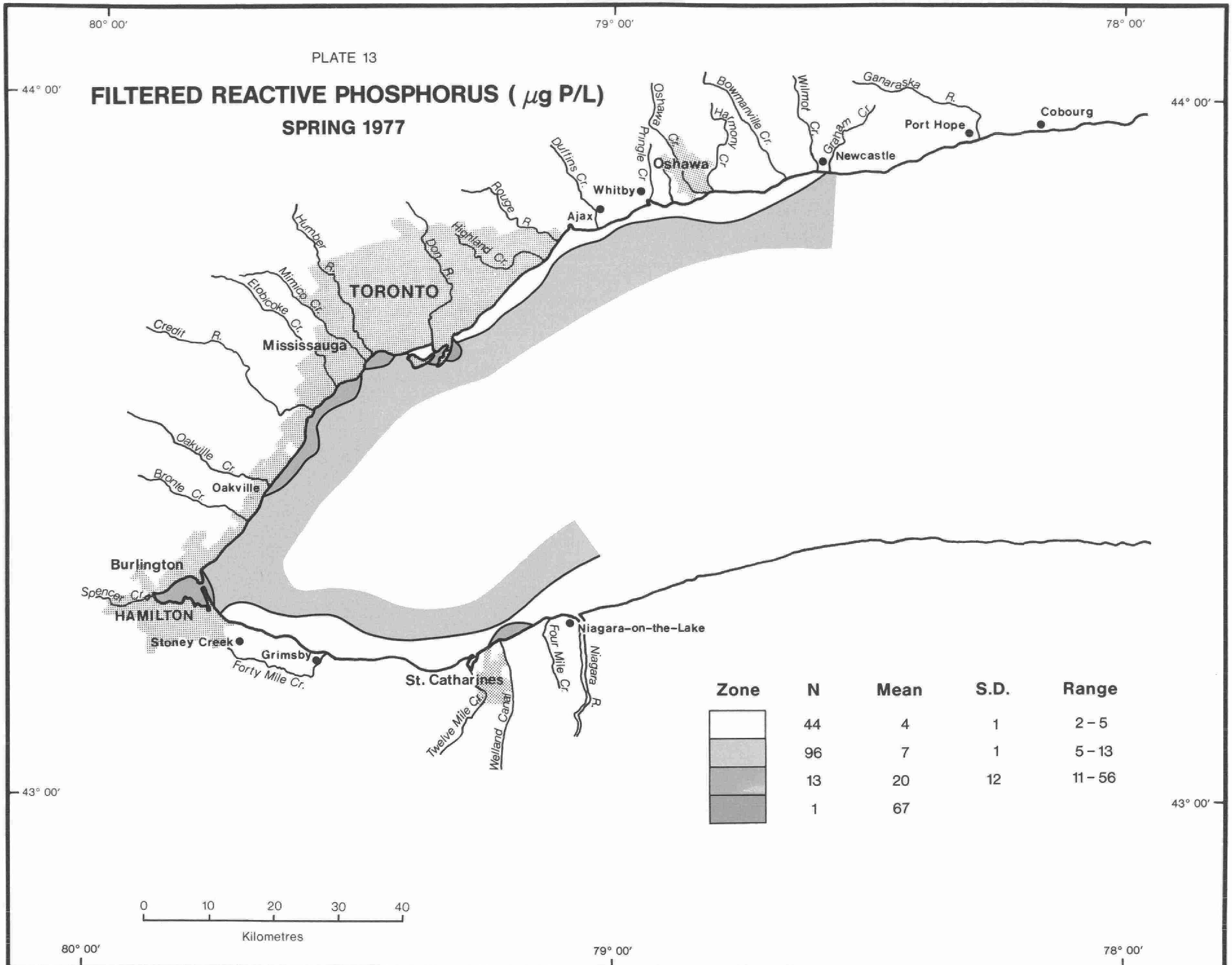


Zone	N	Mean	S.D.	Range
(white)	125	19	7	15 - 24
(light grey)	24	37	16	24 - 88
(dark grey)	5			56 - 508

PLATE 13

FILTERED REACTIVE PHOSPHORUS (μg P/L)

SPRING 1977

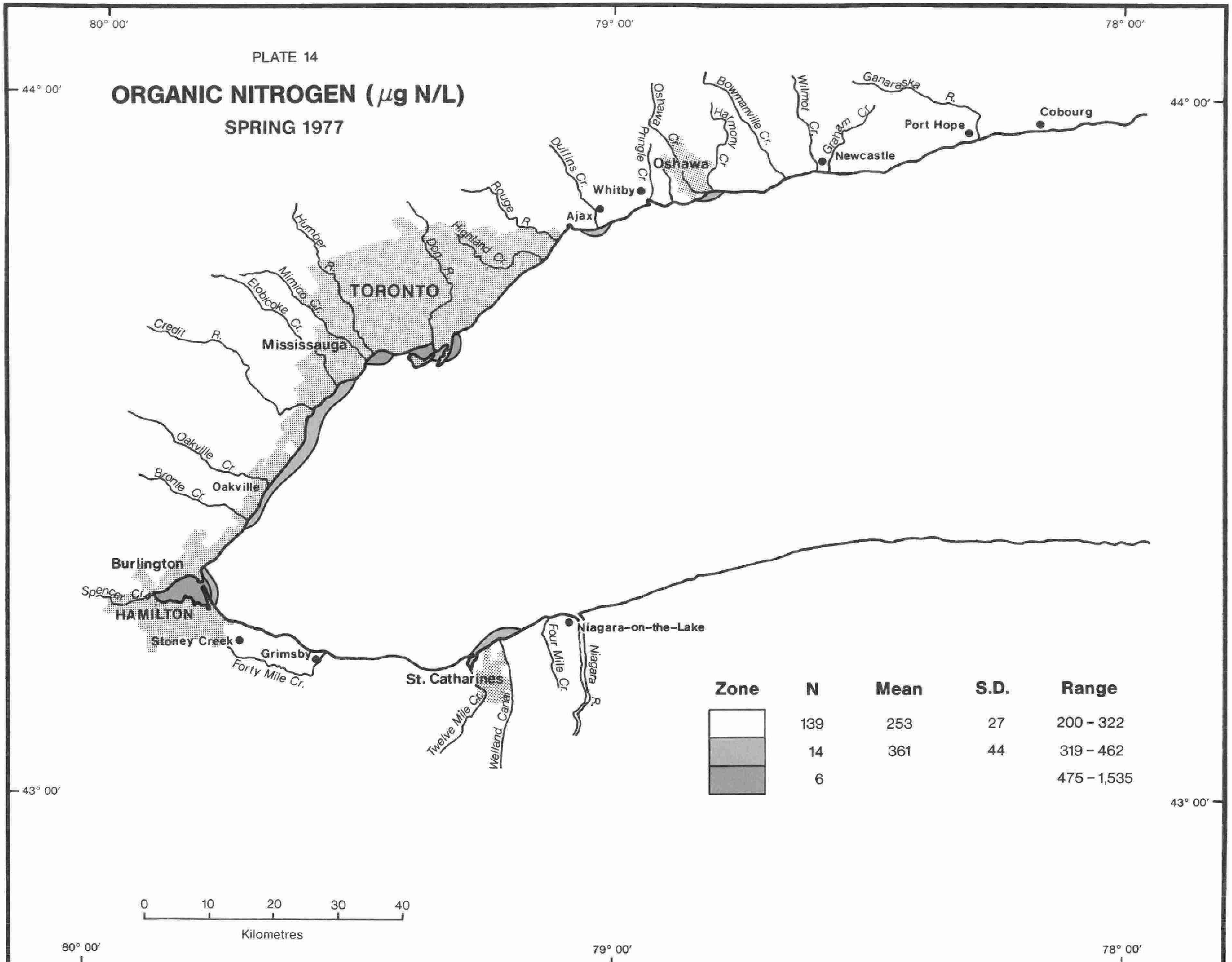


Zone	N	Mean	S.D.	Range
(white)	44	4	1	2 - 5
(light grey)	96	7	1	5 - 13
(medium grey)	13	20	12	11 - 56
(dark grey)	1	67		

PLATE 14

ORGANIC NITROGEN (μg N/L)

SPRING 1977

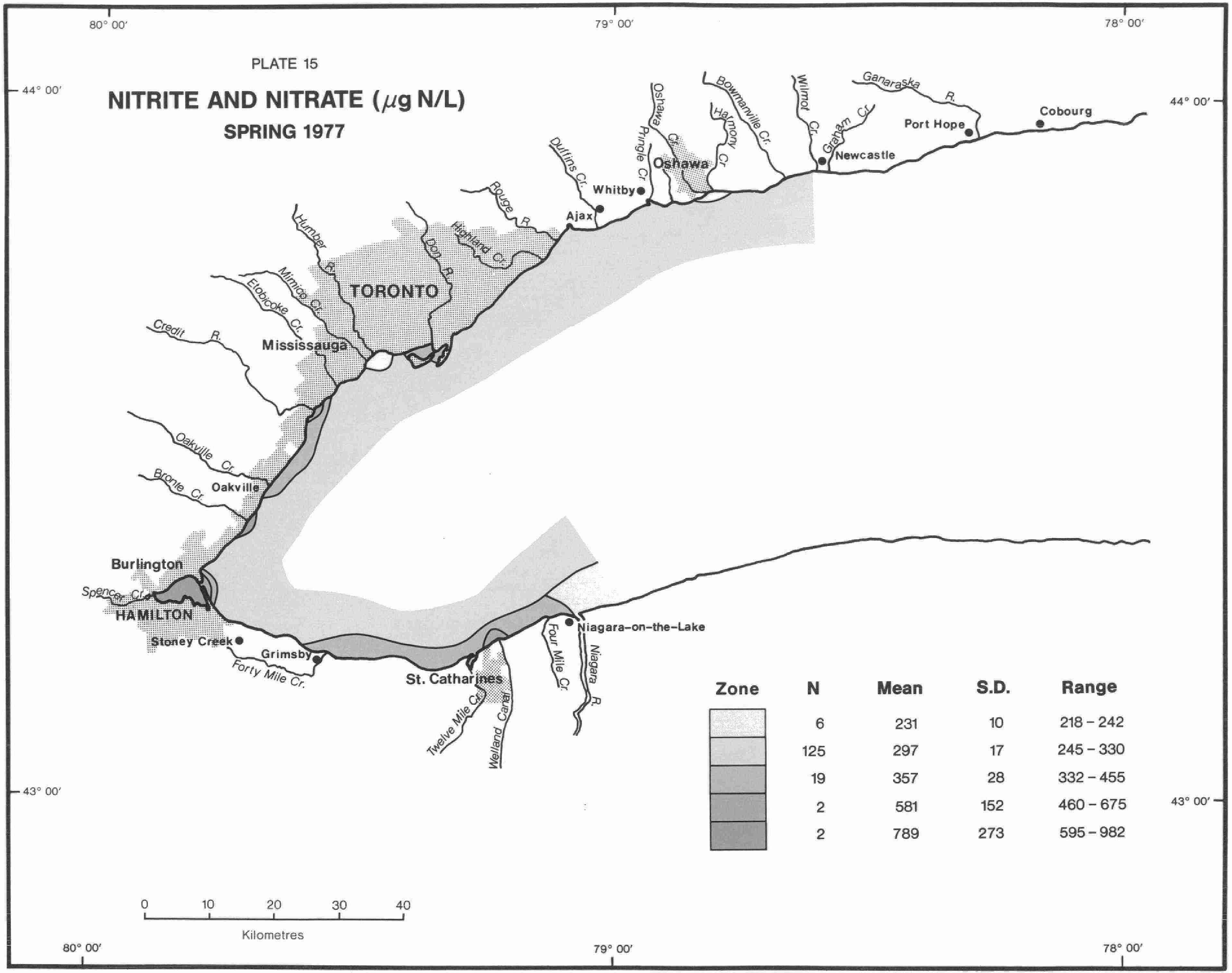


Zone	N	Mean	S.D.	Range
(white)	139	253	27	200 - 322
(light shading)	14	361	44	319 - 462
(dark shading)	6			475 - 1,535

PLATE 15

NITRITE AND NITRATE (μg N/L)

SPRING 1977

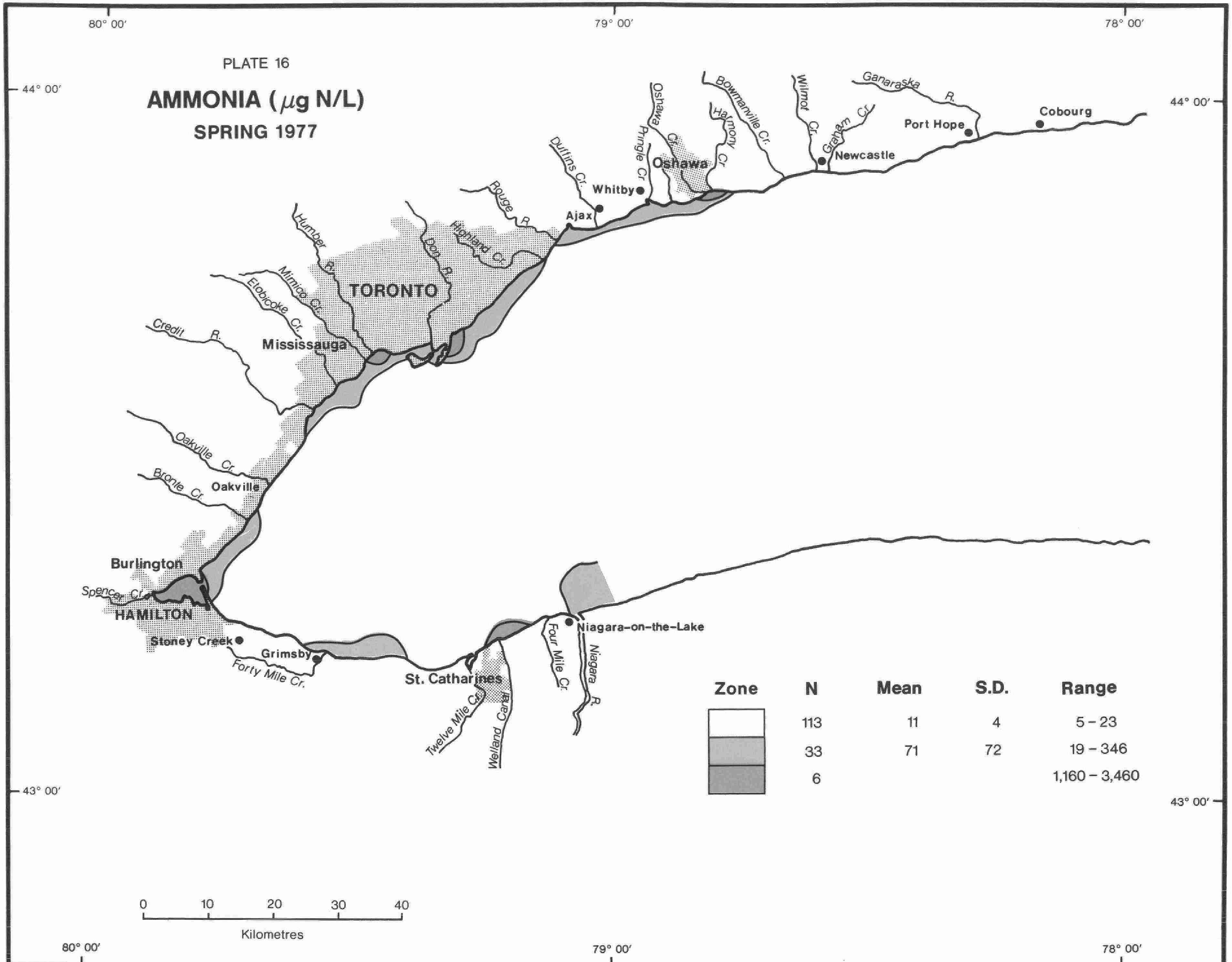


Zone	N	Mean	S.D.	Range
	6	231	10	218 - 242
	125	297	17	245 - 330
	19	357	28	332 - 455
	2	581	152	460 - 675
	2	789	273	595 - 982

PLATE 16

AMMONIA (μg N/L)

SPRING 1977

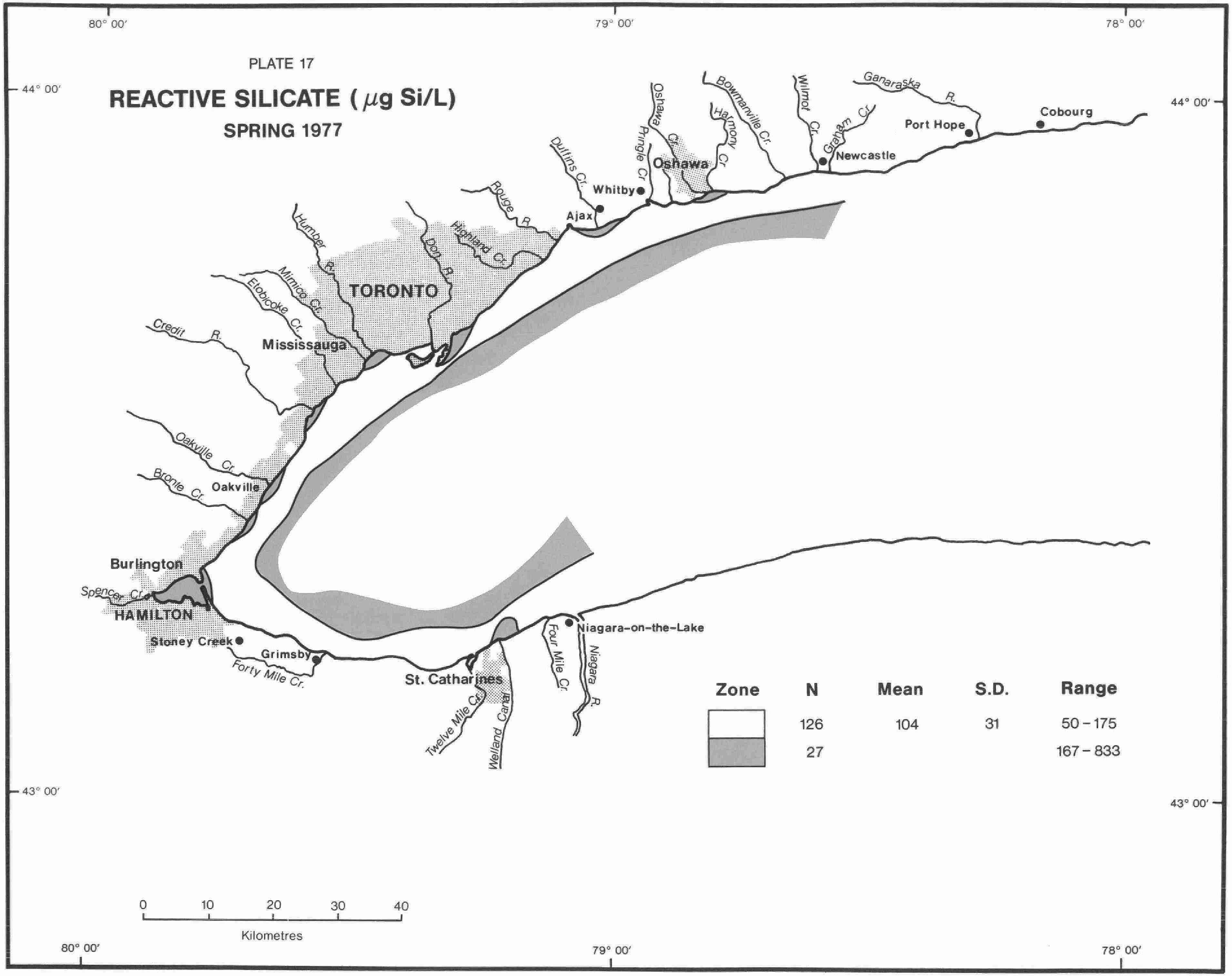


Zone	N	Mean	S.D.	Range
(white)	113	11	4	5 - 23
(light grey)	33	71	72	19 - 346
(dark grey)	6			1,160 - 3,460

PLATE 17

REACTIVE SILICATE (μg Si/L)

SPRING 1977



Zone	N	Mean	S.D.	Range
(white)	126	104	31	50 – 175
(shaded)	27			167 – 833

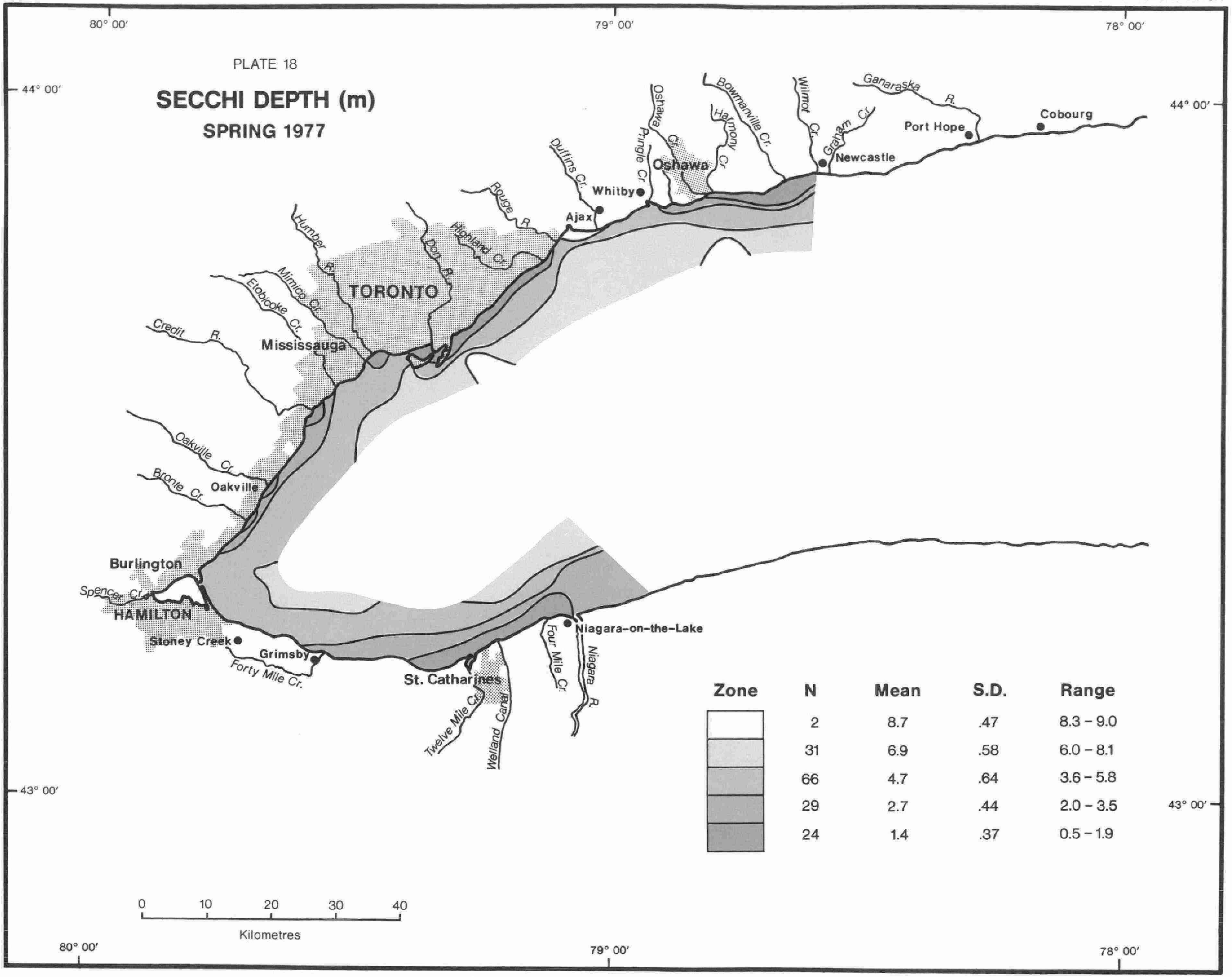


PLATE 18

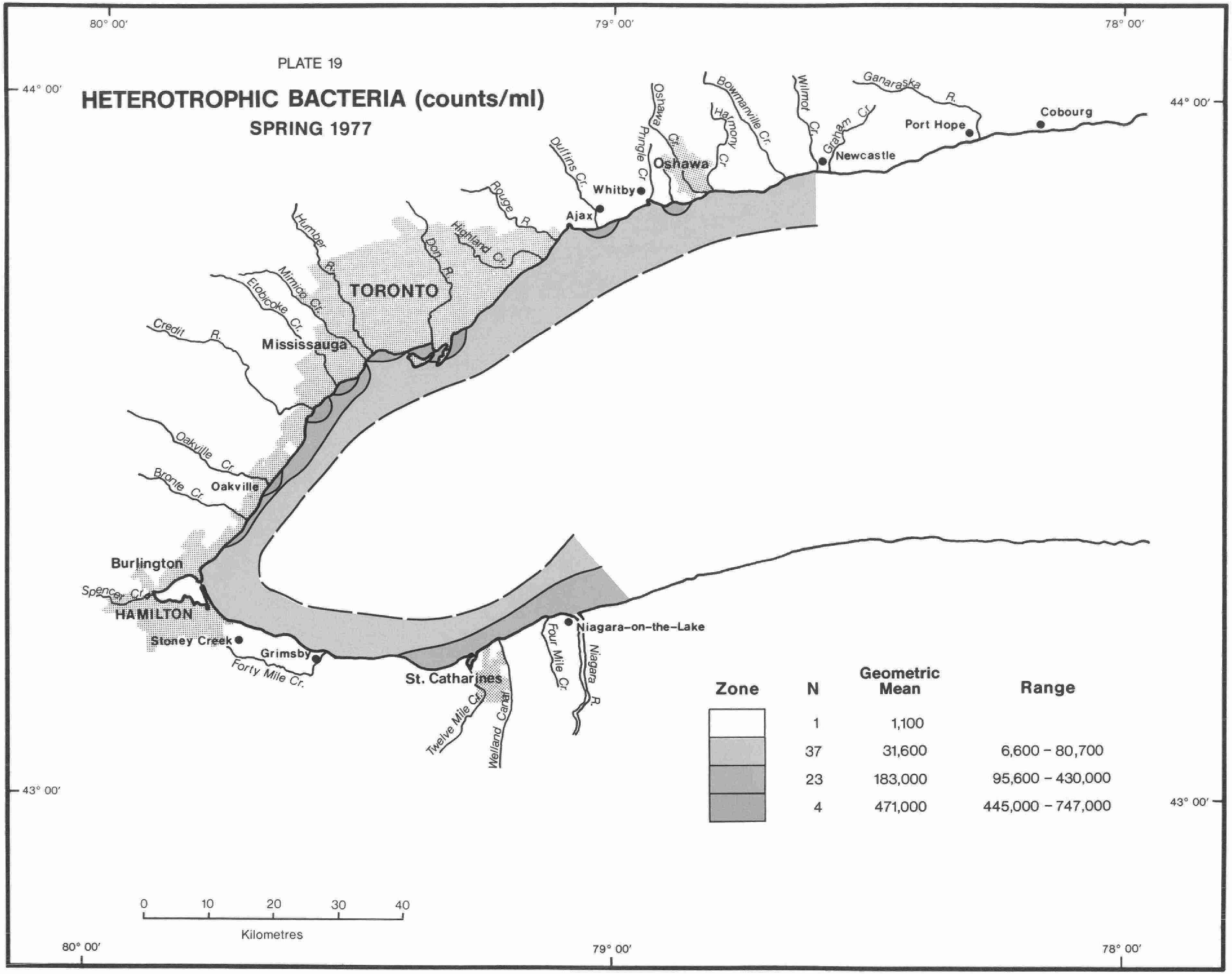
SECCHI DEPTH (m)

SPRING 1977

Zone	N	Mean	S.D.	Range
	2	8.7	.47	8.3 – 9.0
	31	6.9	.58	6.0 – 8.1
	66	4.7	.64	3.6 – 5.8
	29	2.7	.44	2.0 – 3.5
	24	1.4	.37	0.5 – 1.9

PLATE 19

HETEROTROPHIC BACTERIA (counts/ml)
SPRING 1977

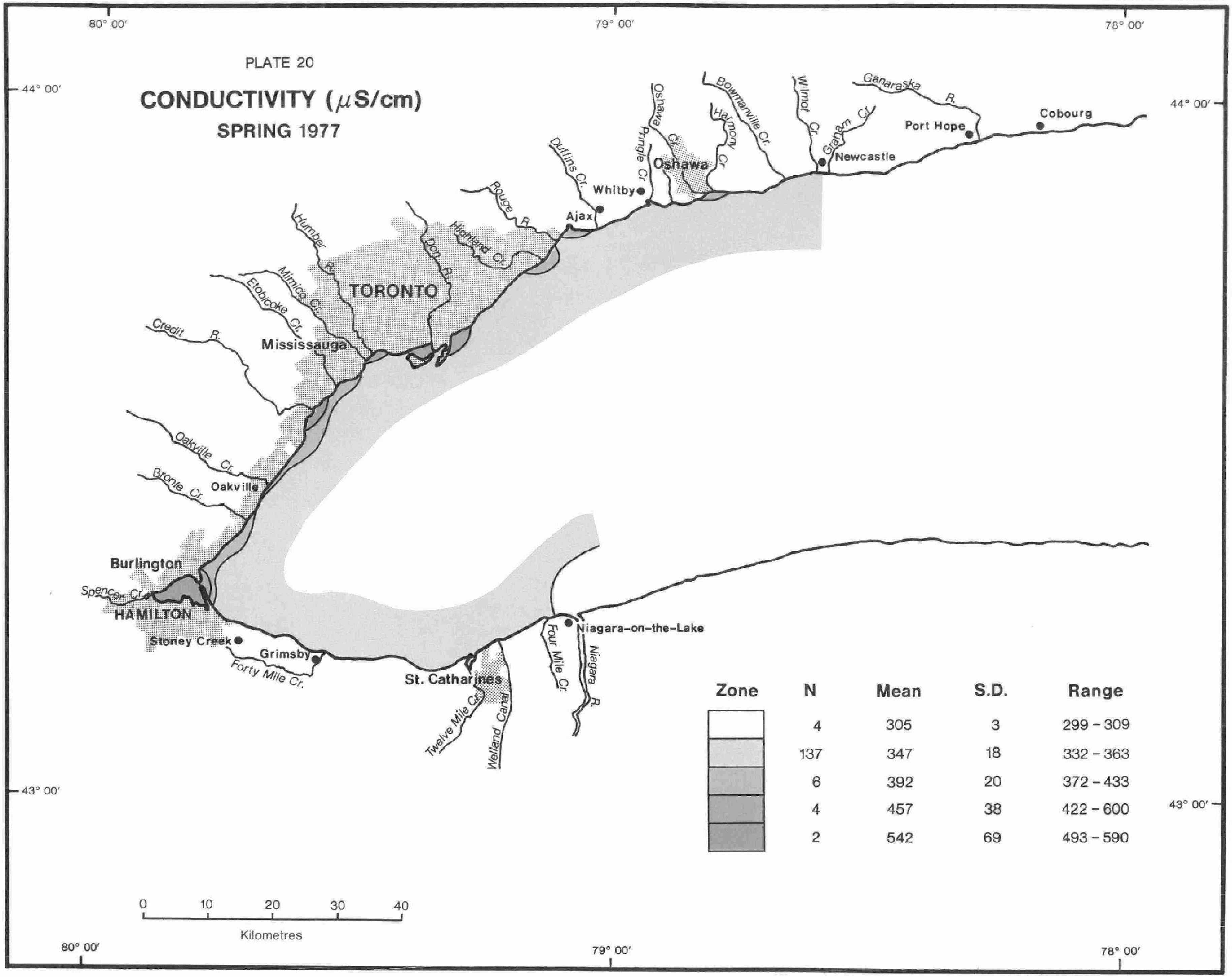


Zone	N	Geometric Mean	Range
1	1	1,100	
2	37	31,600	6,600 - 80,700
3	23	183,000	95,600 - 430,000
4	4	471,000	445,000 - 747,000

PLATE 20

CONDUCTIVITY (μS/cm)

SPRING 1977



Zone	N	Mean	S.D.	Range
	4	305	3	299 - 309
	137	347	18	332 - 363
	6	392	20	372 - 433
	4	457	38	422 - 600
	2	542	69	493 - 590

PLATE 21

TEMPERATURE (°C)

SPRING 1977

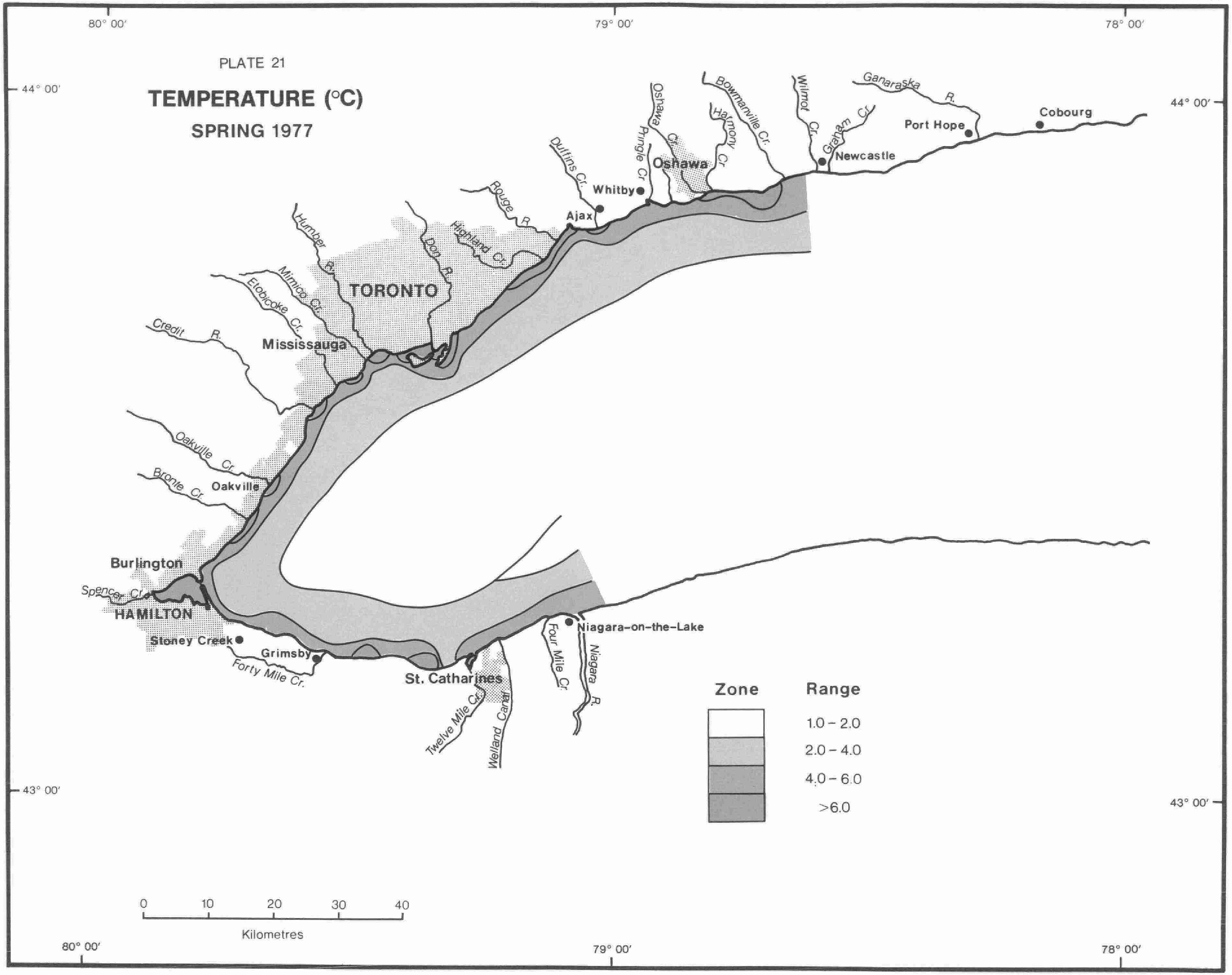
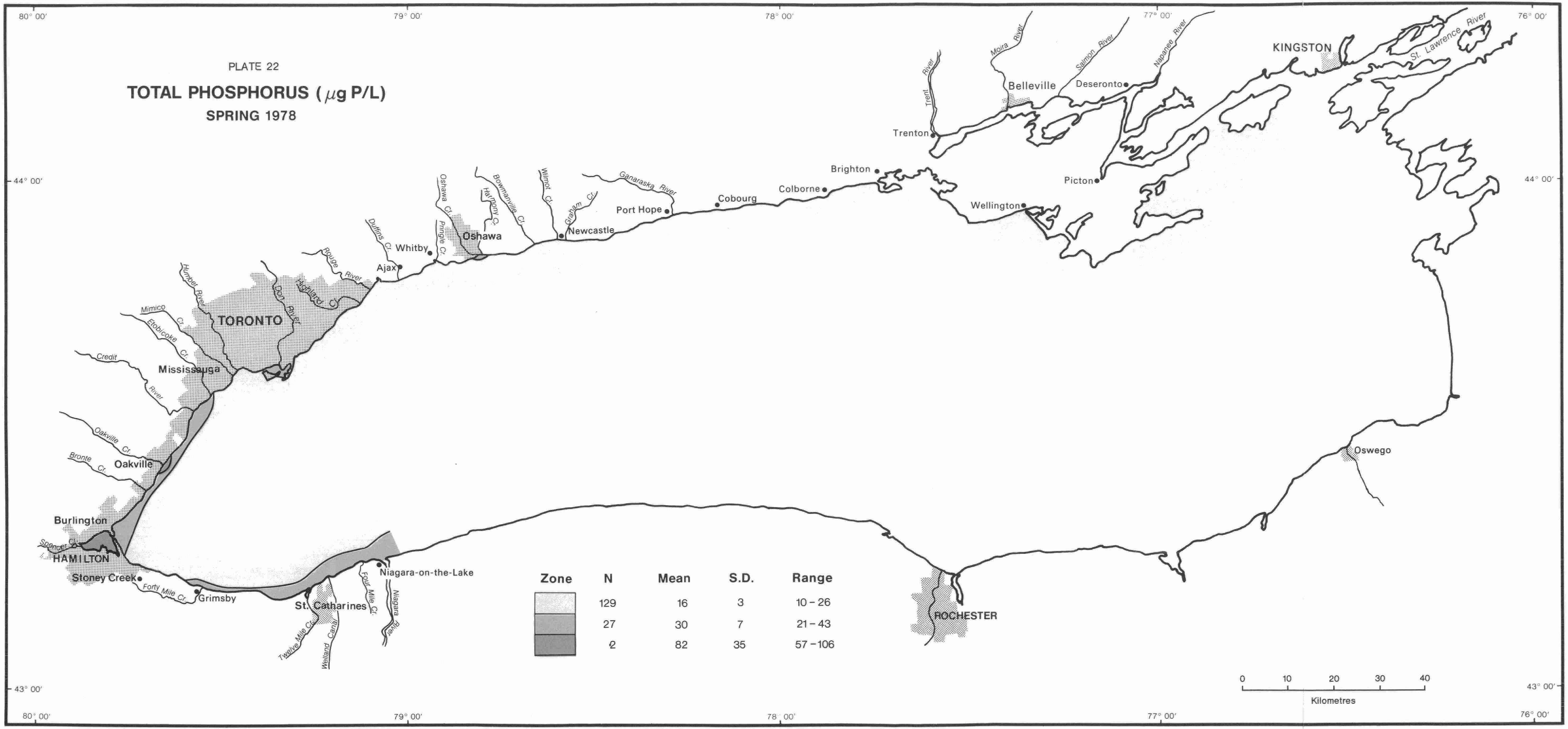


PLATE 22

TOTAL PHOSPHORUS (μg P/L)

SPRING 1978

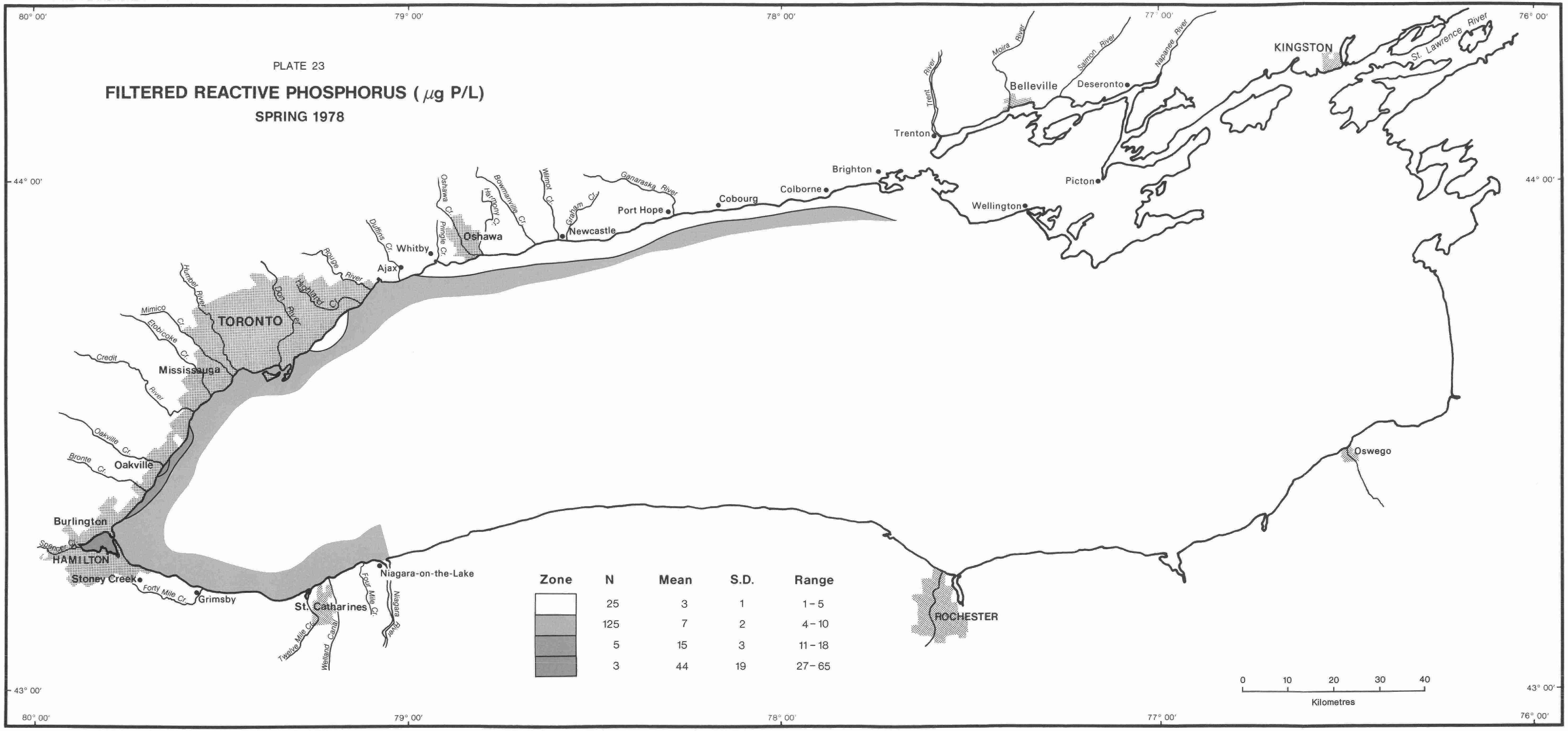


Zone	N	Mean	S.D.	Range
(light)	129	16	3	10 - 26
(medium)	27	30	7	21 - 43
(dark)	2	82	35	57 - 106

PLATE 23

FILTERED REACTIVE PHOSPHORUS (μg P/L)

SPRING 1978

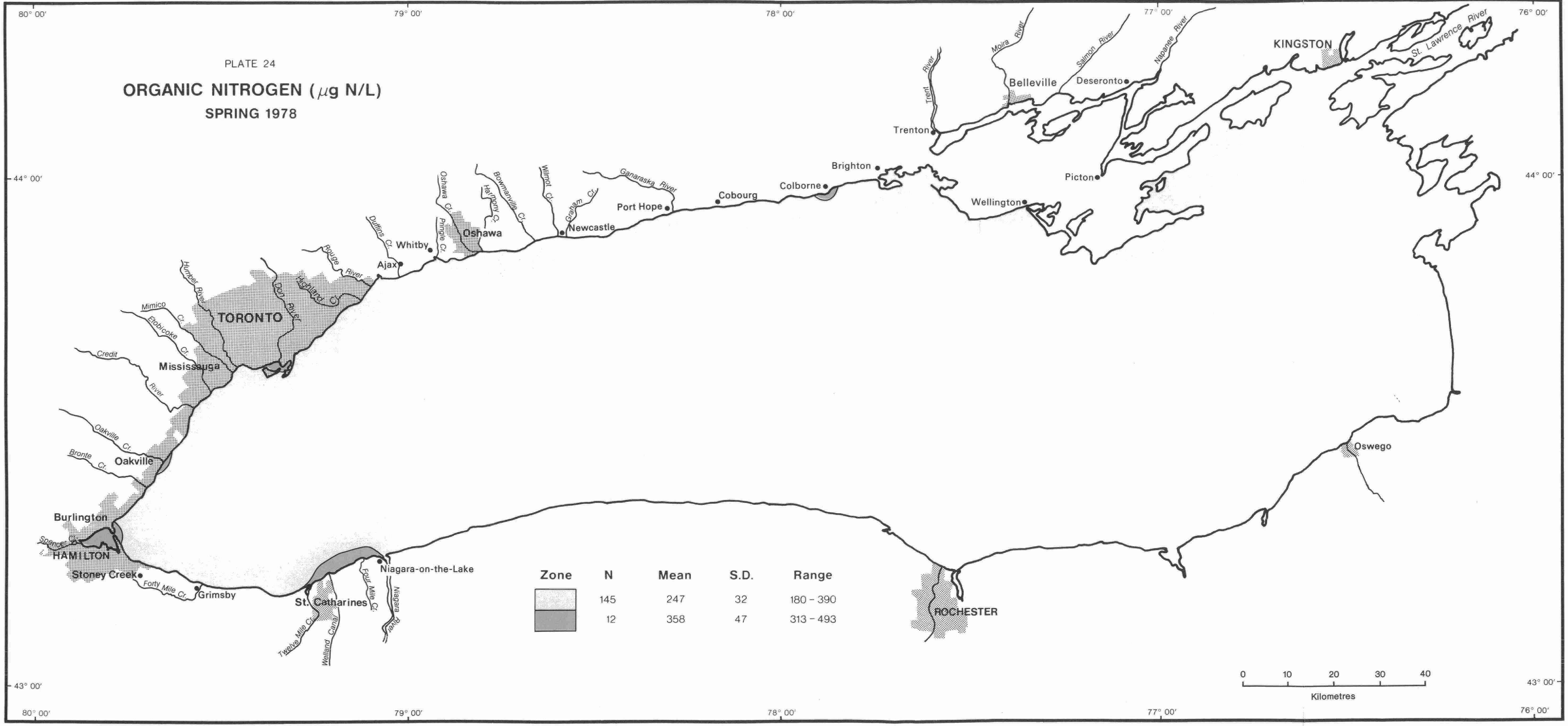


Zone	N	Mean	S.D.	Range
(white)	25	3	1	1-5
(light grey)	125	7	2	4-10
(medium grey)	5	15	3	11-18
(dark grey)	3	44	19	27-65

PLATE 24

ORGANIC NITROGEN (μg N/L)

SPRING 1978

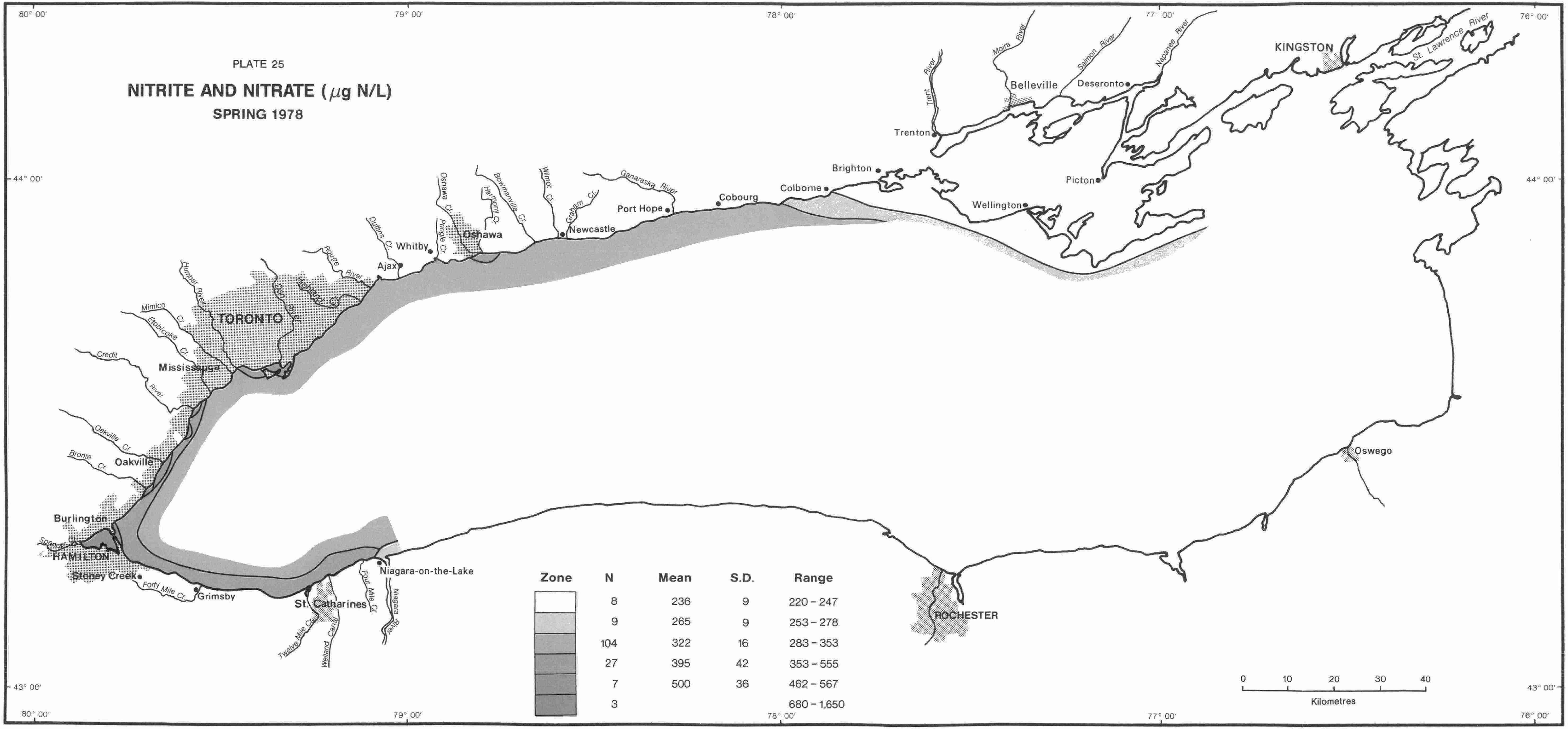


Zone	N	Mean	S.D.	Range
(light)	145	247	32	180 - 390
(dark)	12	358	47	313 - 493

PLATE 25

NITRITE AND NITRATE (μg N/L)

SPRING 1978

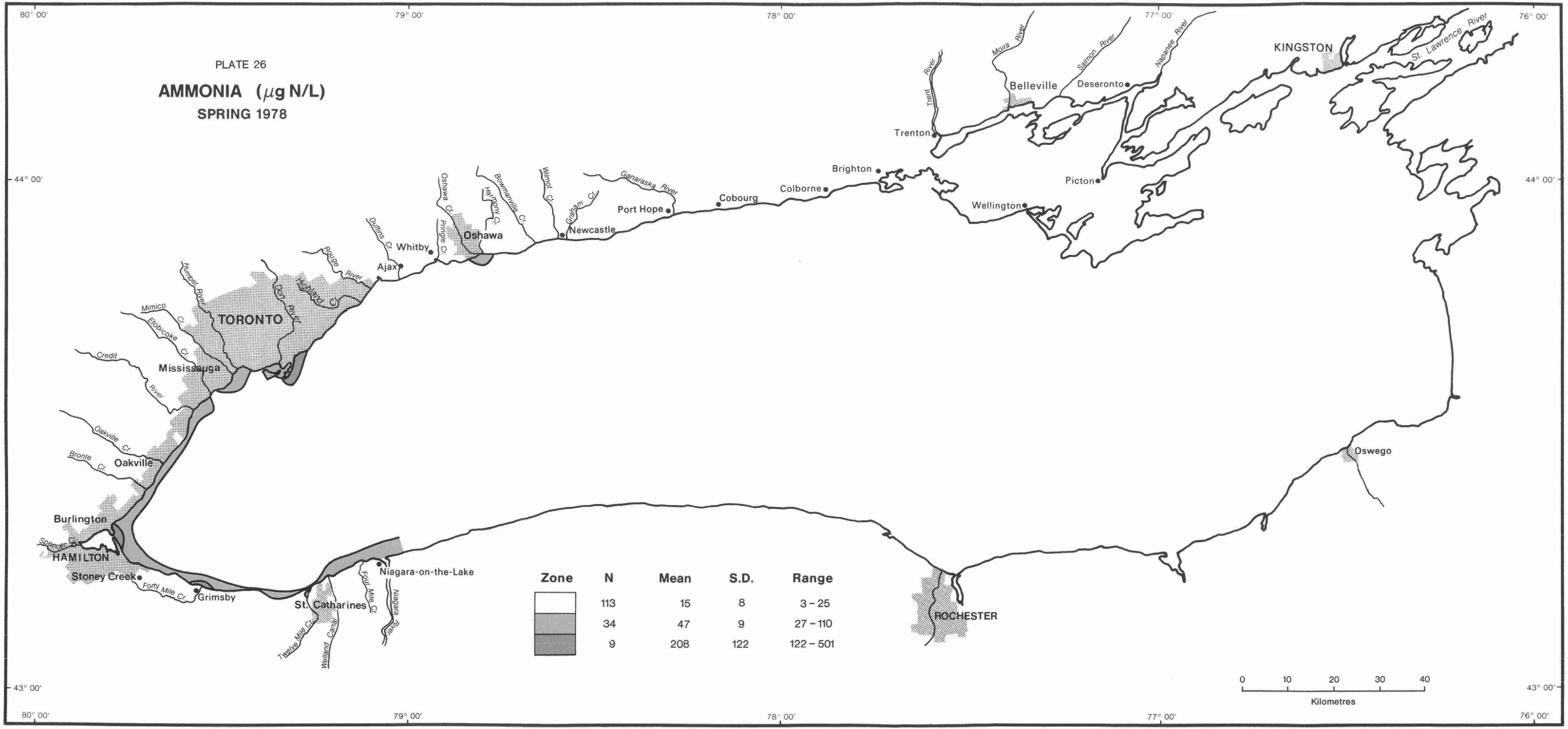


Zone	N	Mean	S.D.	Range
	8	236	9	220 - 247
	9	265	9	253 - 278
	104	322	16	283 - 353
	27	395	42	353 - 555
	7	500	36	462 - 567
	3			680 - 1,650

PLATE 26

AMMONIA (μg N/L)

SPRING 1978

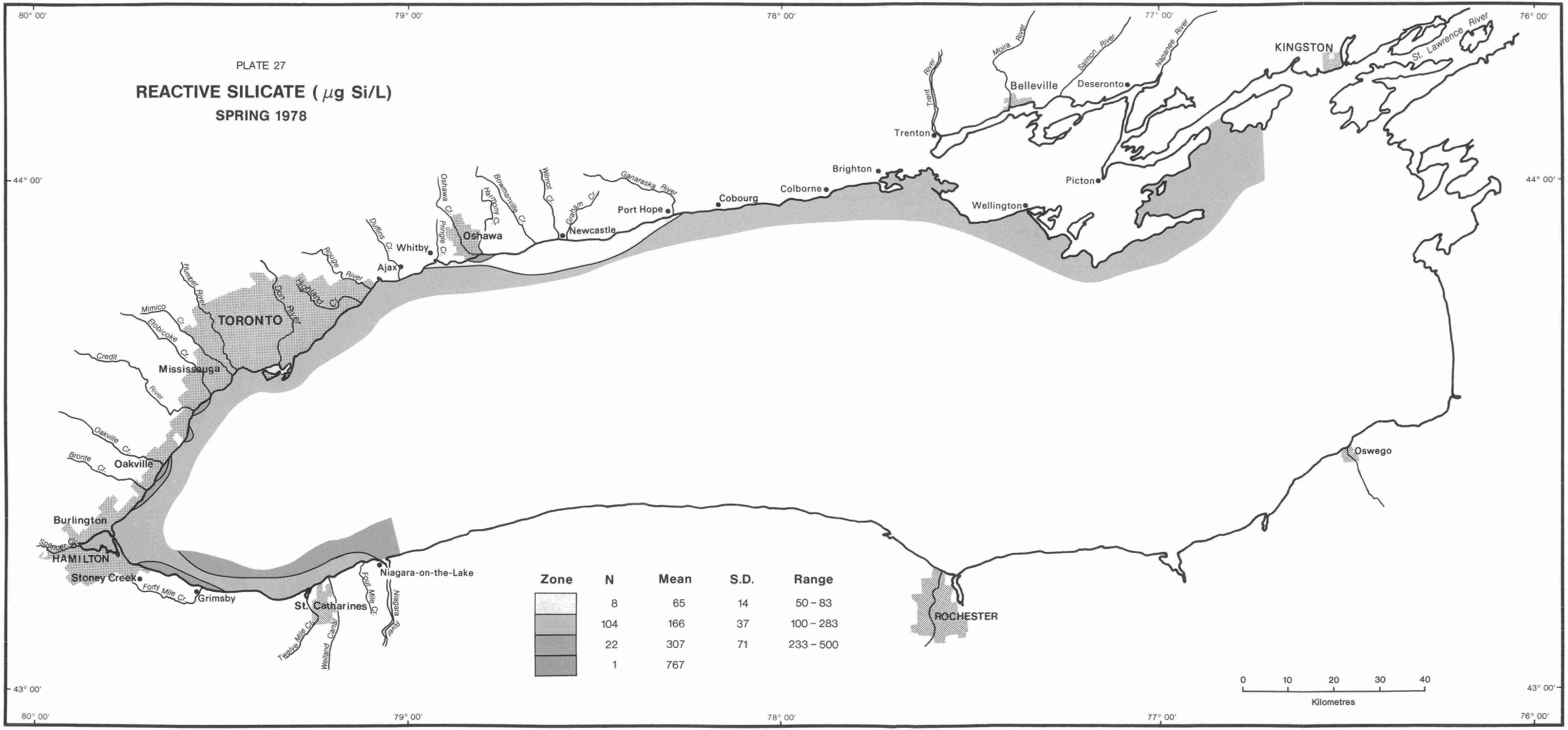


Zone	N	Mean	S.D.	Range
(white)	113	15	8	3 - 25
(light grey)	34	47	9	27 - 110
(dark grey)	9	208	122	122 - 501

PLATE 27

REACTIVE SILICATE (μg Si/L)

SPRING 1978

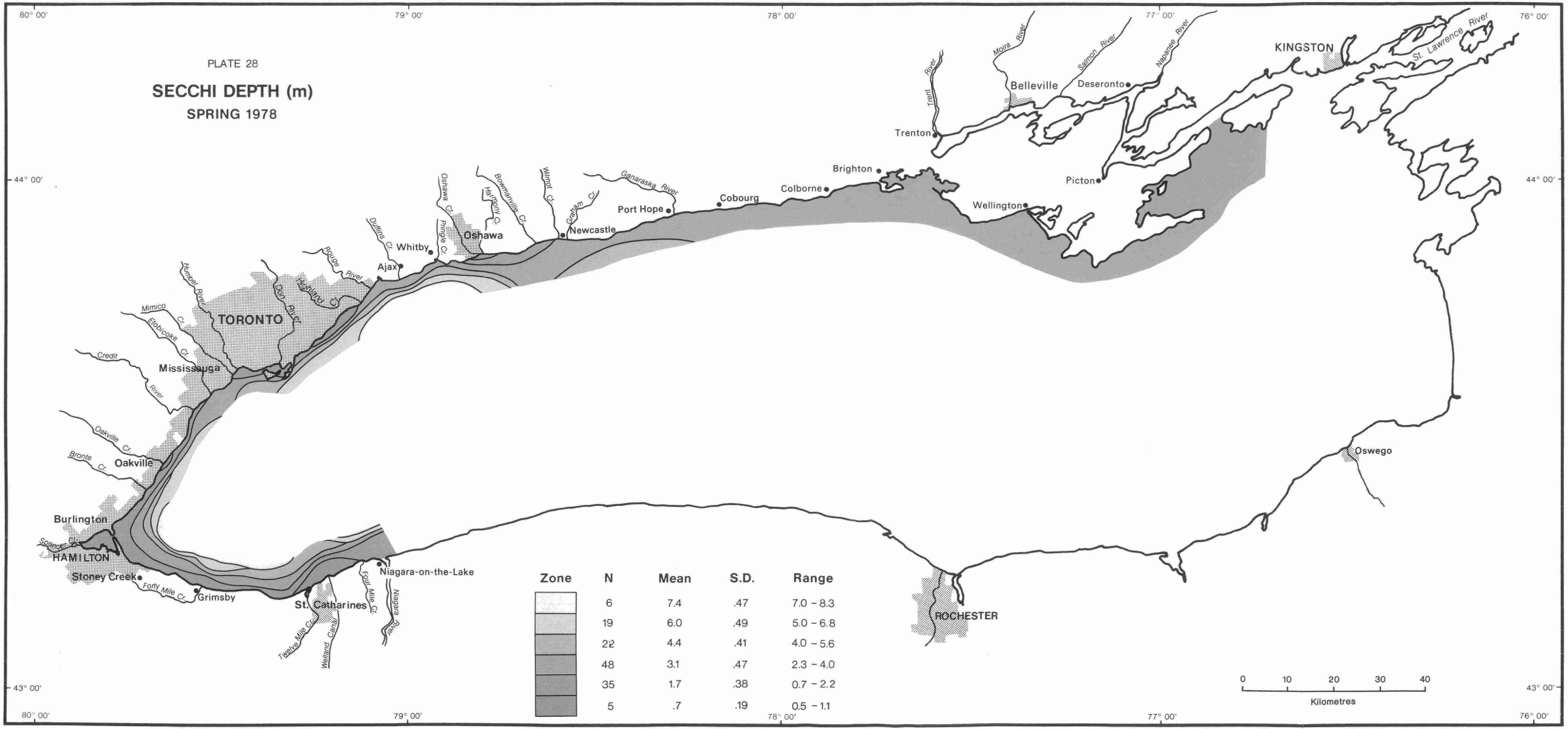


Zone	N	Mean	S.D.	Range
	8	65	14	50 – 83
	104	166	37	100 – 283
	22	307	71	233 – 500
	1	767		

PLATE 28

SECCHI DEPTH (m)

SPRING 1978

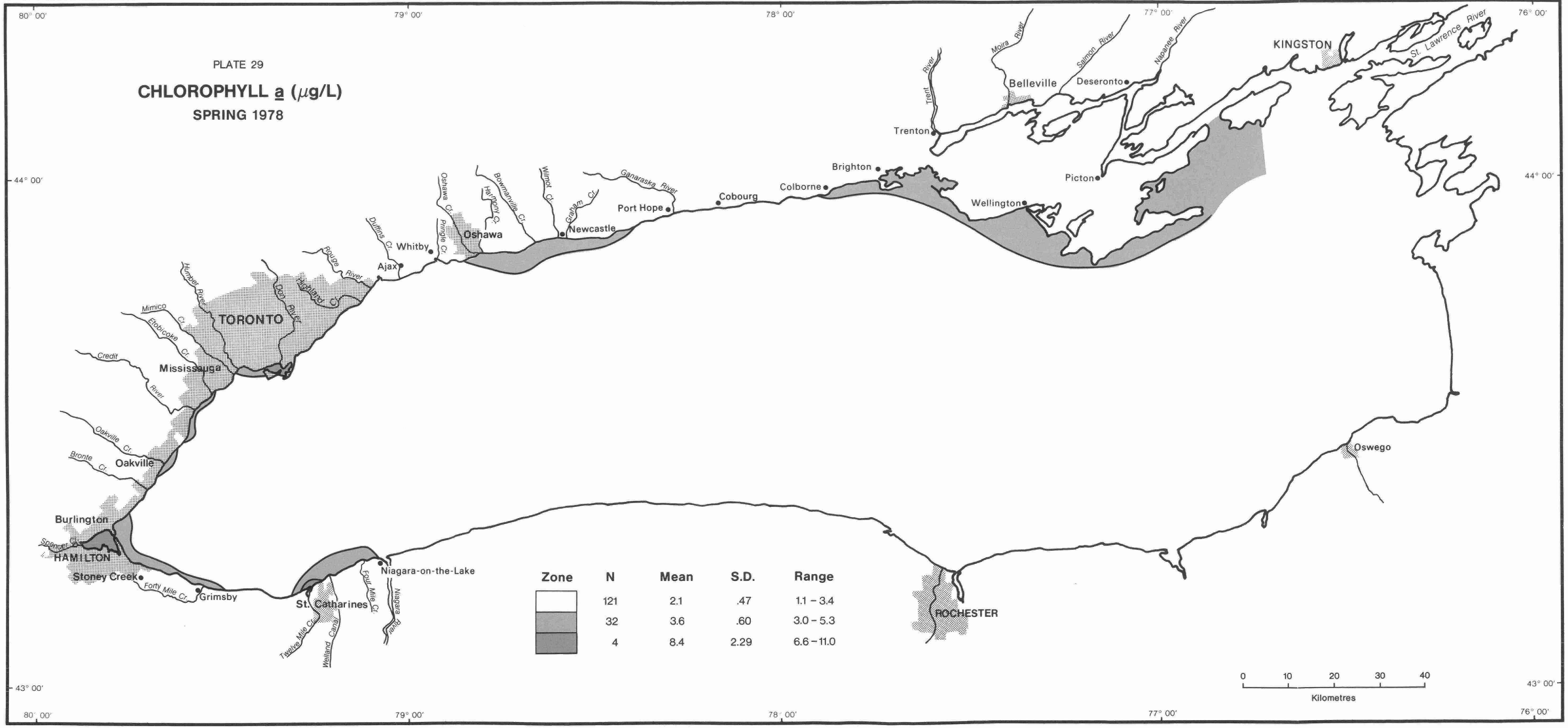


Zone	N	Mean	S.D.	Range
	6	7.4	.47	7.0 – 8.3
	19	6.0	.49	5.0 – 6.8
	22	4.4	.41	4.0 – 5.6
	48	3.1	.47	2.3 – 4.0
	35	1.7	.38	0.7 – 2.2
	5	.7	.19	0.5 – 1.1

PLATE 29

CHLOROPHYLL a (μg/L)

SPRING 1978

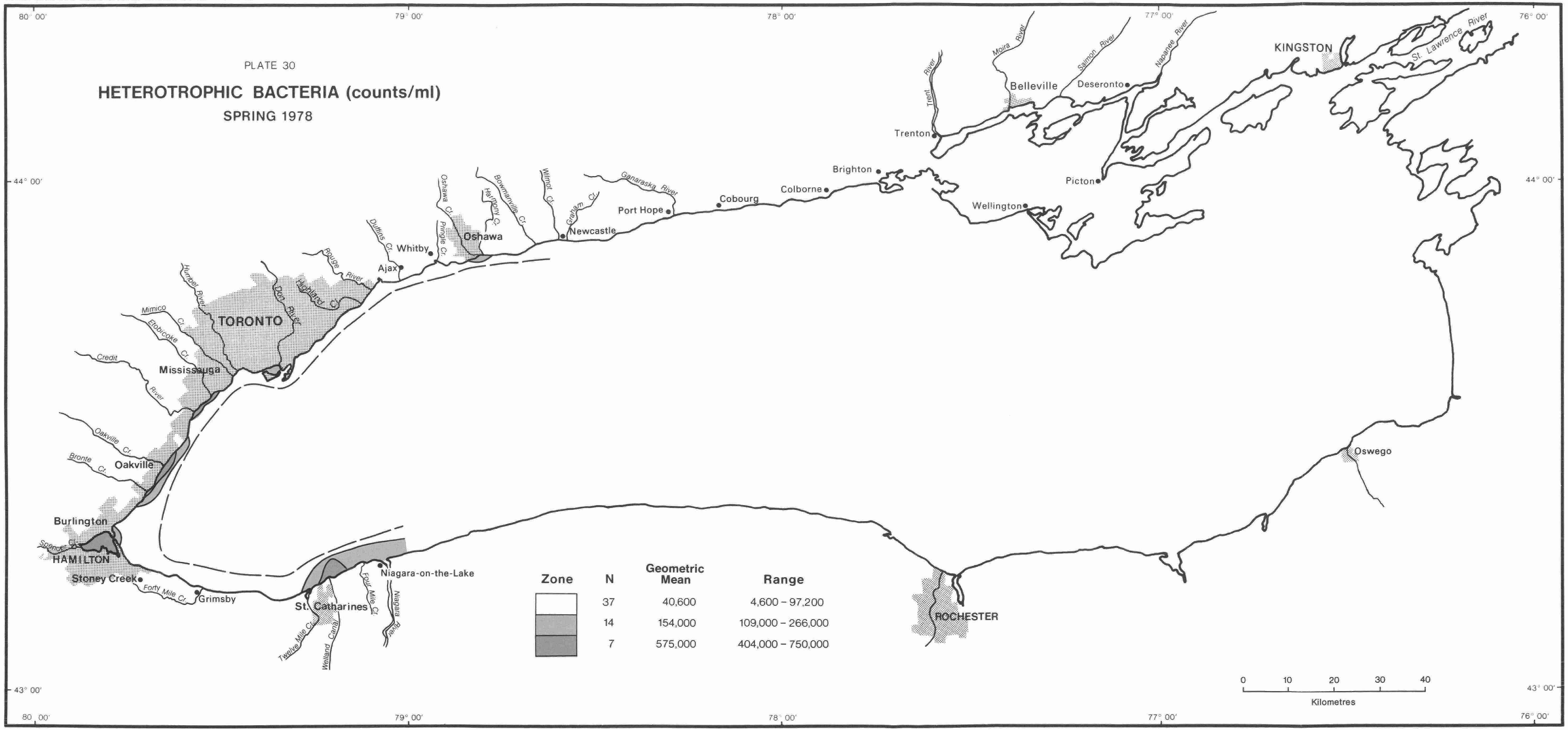


Zone	N	Mean	S.D.	Range
(white)	121	2.1	.47	1.1 – 3.4
(light grey)	32	3.6	.60	3.0 – 5.3
(dark grey)	4	8.4	2.29	6.6 – 11.0

PLATE 30

HETEROTROPHIC BACTERIA (counts/ml)

SPRING 1978



Zone	N	Geometric Mean	Range
(white)	37	40,600	4,600 – 97,200
(light grey)	14	154,000	109,000 – 266,000
(dark grey)	7	575,000	404,000 – 750,000

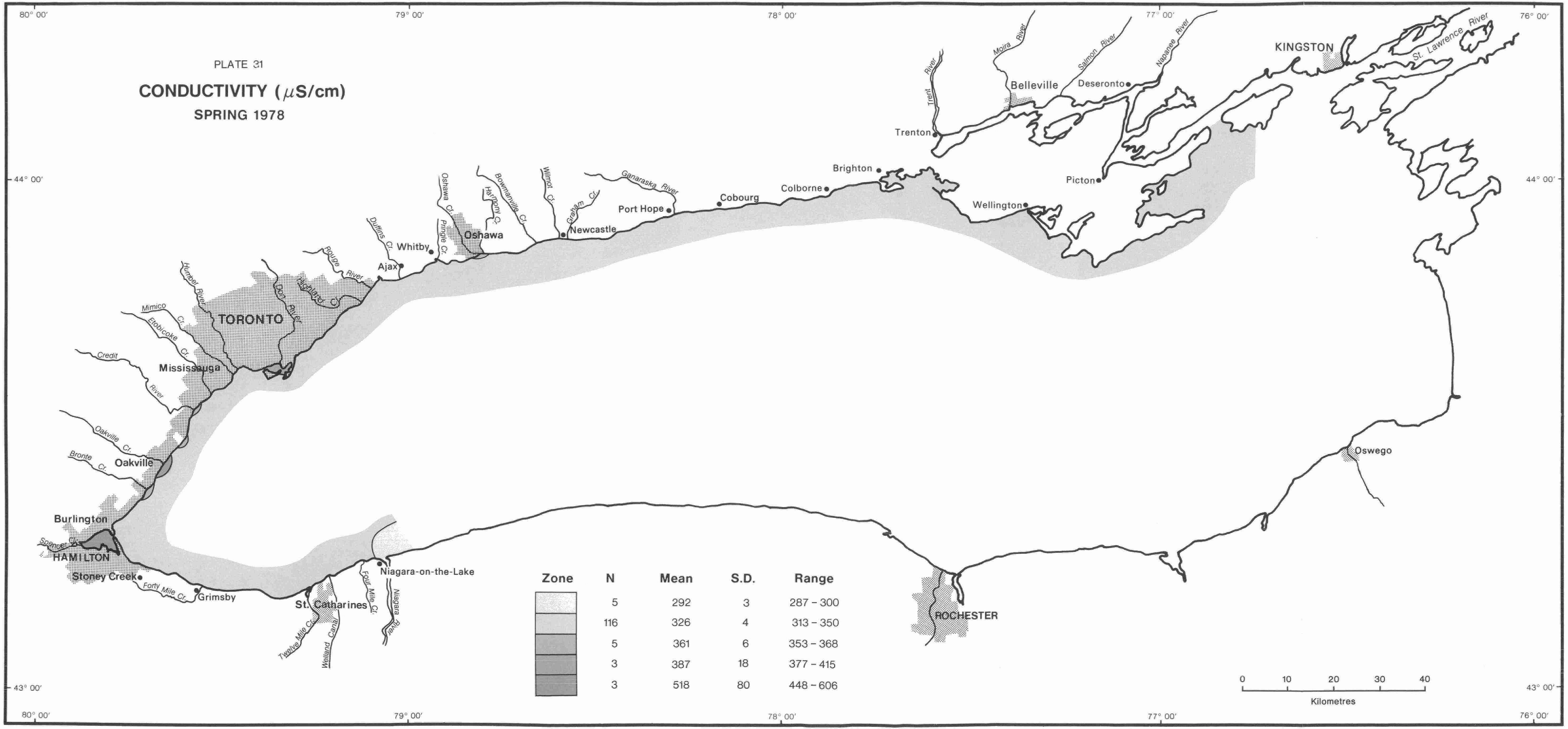


PLATE 31

CONDUCTIVITY (μS/cm)

SPRING 1978

Zone	N	Mean	S.D.	Range
1	5	292	3	287 - 300
2	116	326	4	313 - 350
3	5	361	6	353 - 368
4	3	387	18	377 - 415
5	3	518	80	448 - 606

PLATE 32

TEMPERATURE (°C)

SPRING 1978

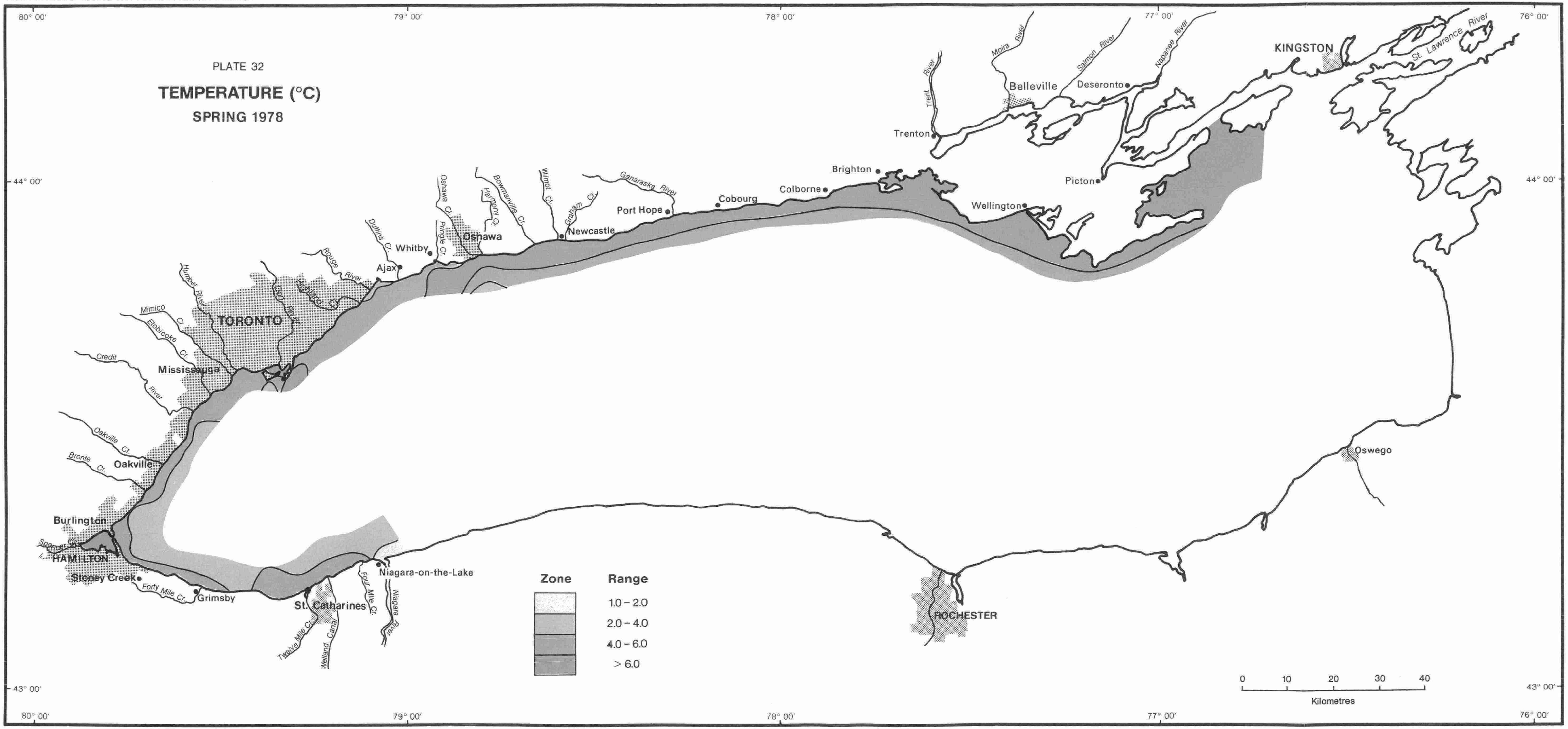
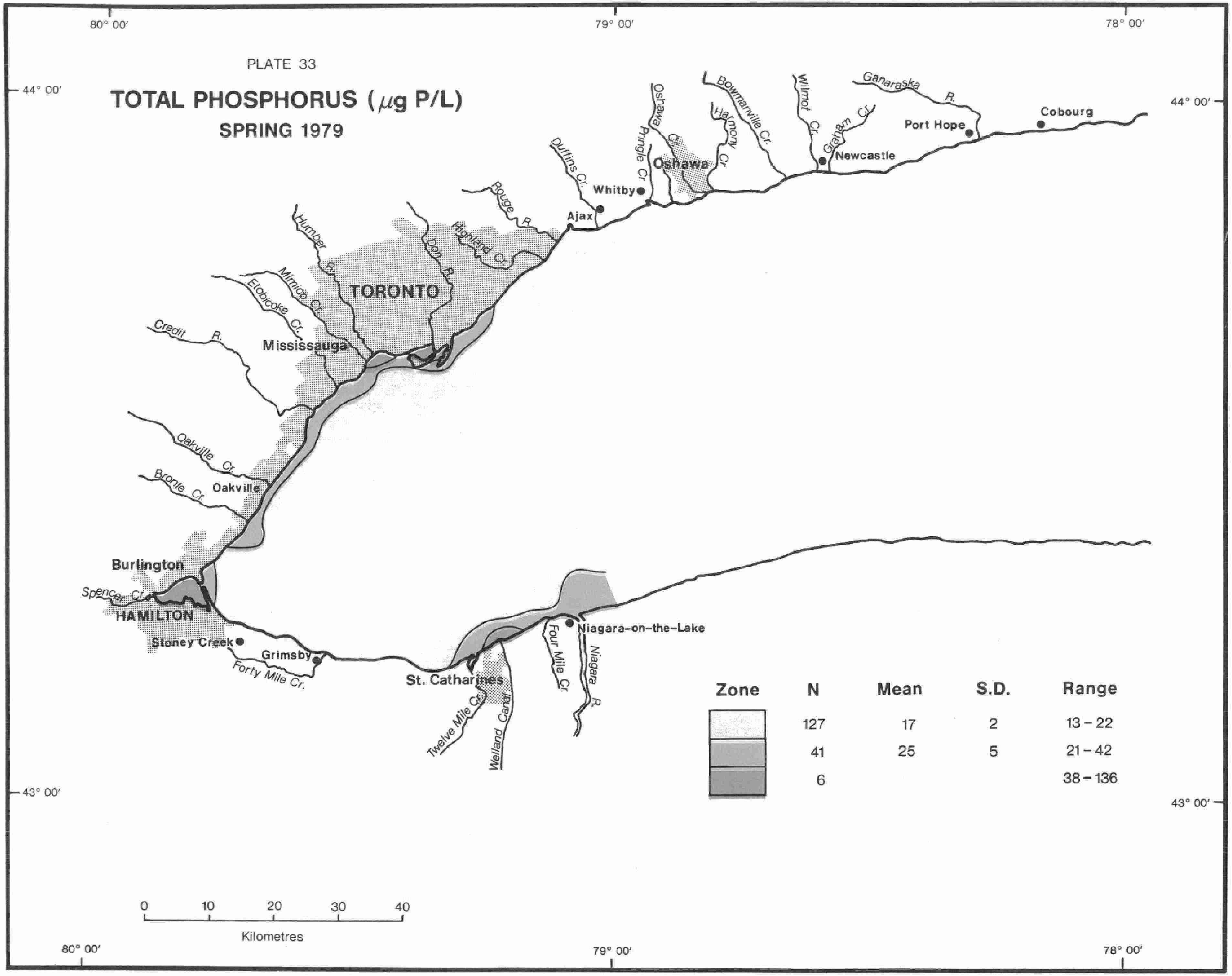


PLATE 33

TOTAL PHOSPHORUS (μg P/L)
SPRING 1979

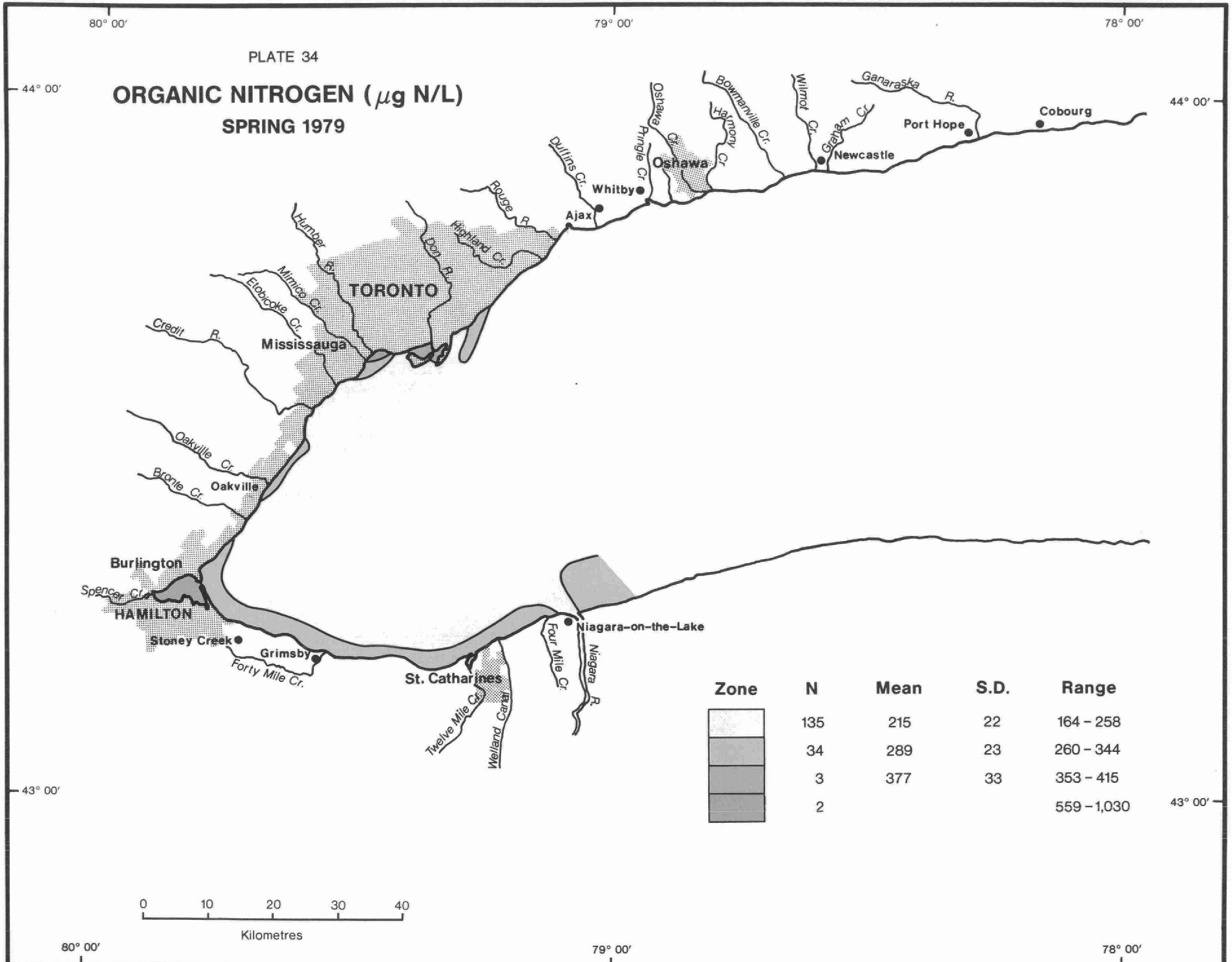


Zone	N	Mean	S.D.	Range
(lightest shading)	127	17	2	13 - 22
(medium shading)	41	25	5	21 - 42
(darkest shading)	6			38 - 136

PLATE 34

ORGANIC NITROGEN (μg N/L)

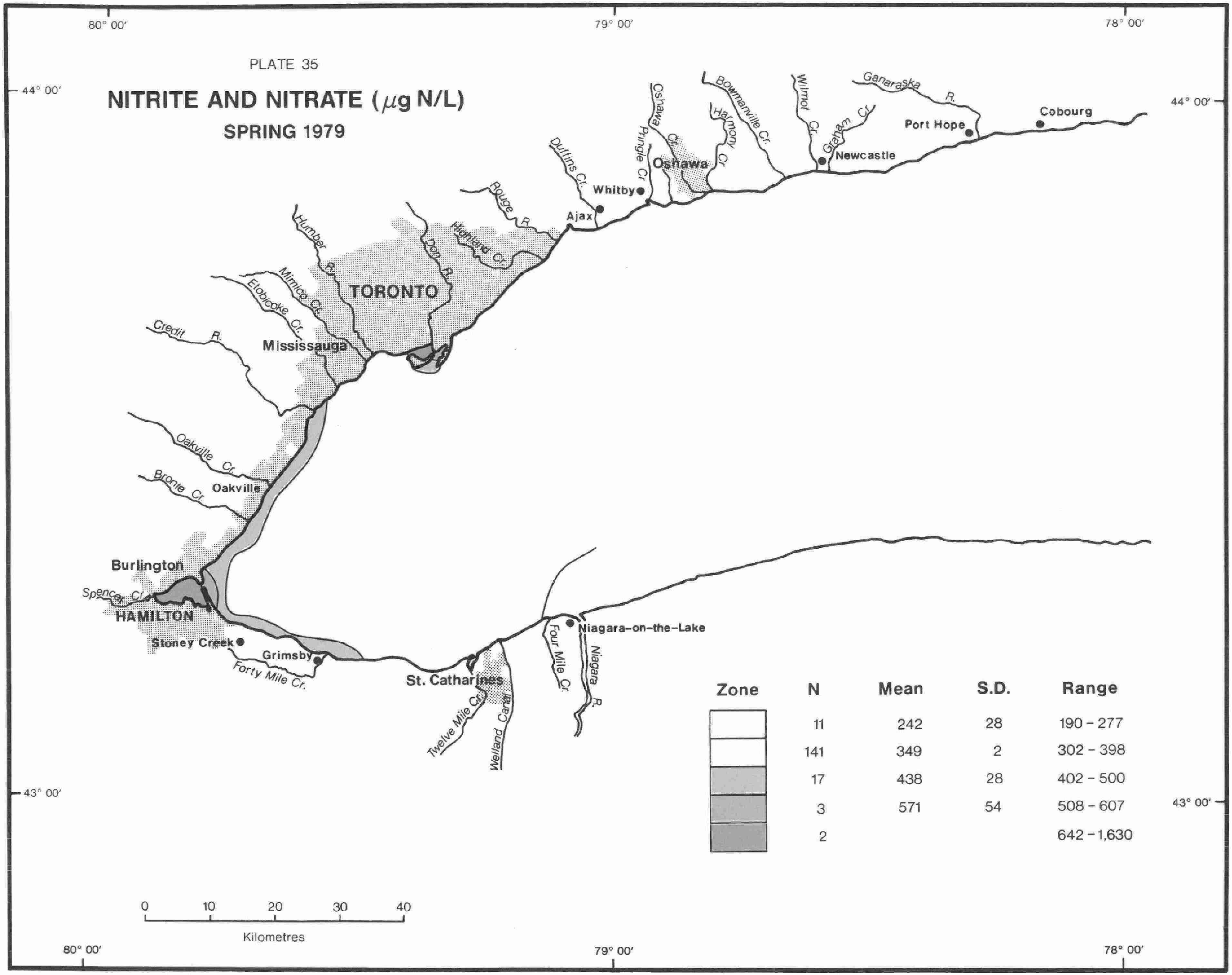
SPRING 1979



Zone	N	Mean	S.D.	Range
	135	215	22	164 - 258
	34	289	23	260 - 344
	3	377	33	353 - 415
	2			559 - 1,030

PLATE 35

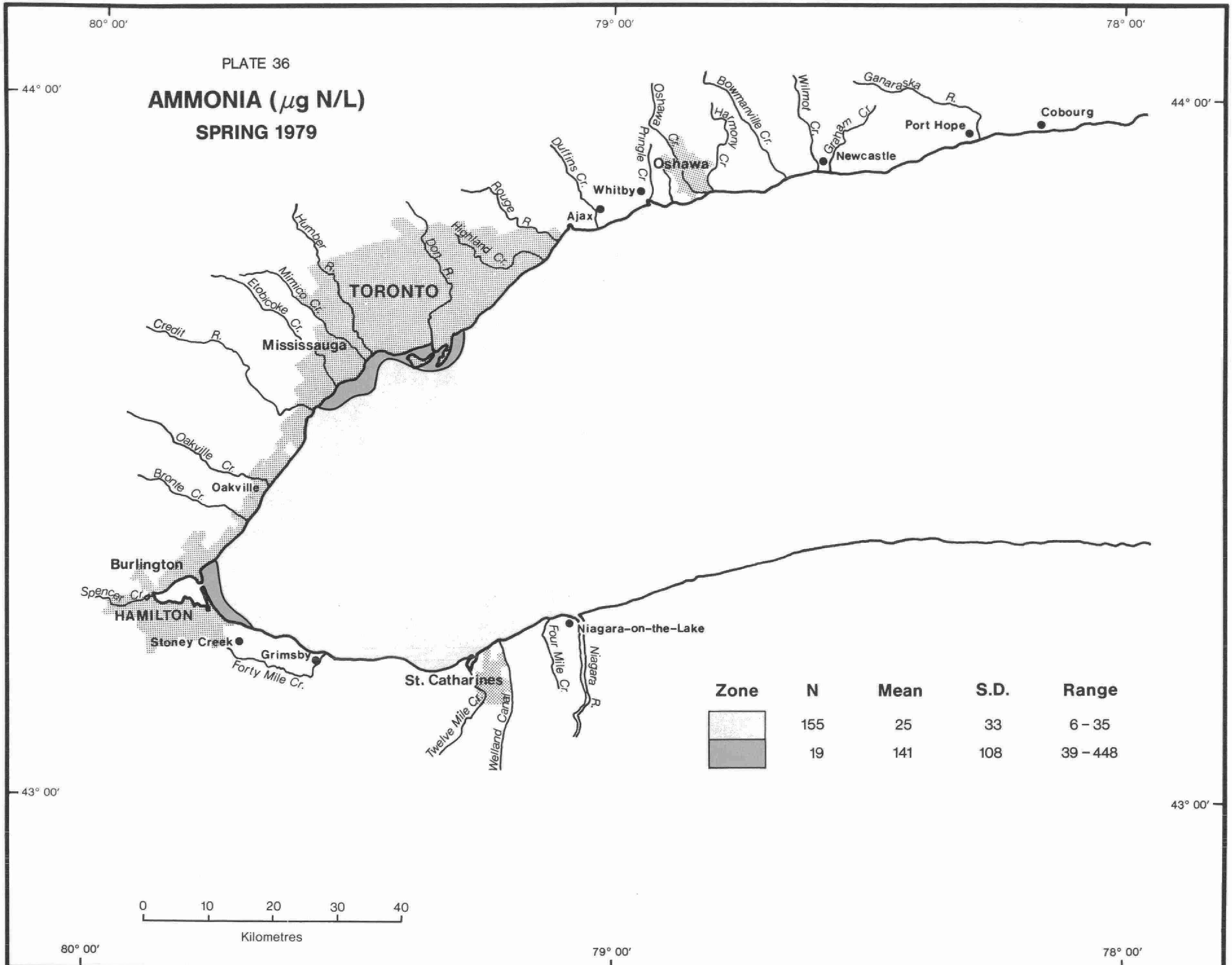
NITRITE AND NITRATE (μg N/L)
SPRING 1979



Zone	N	Mean	S.D.	Range
	11	242	28	190 – 277
	141	349	2	302 – 398
	17	438	28	402 – 500
	3	571	54	508 – 607
	2			642 – 1,630

PLATE 36

AMMONIA (μg N/L)
SPRING 1979

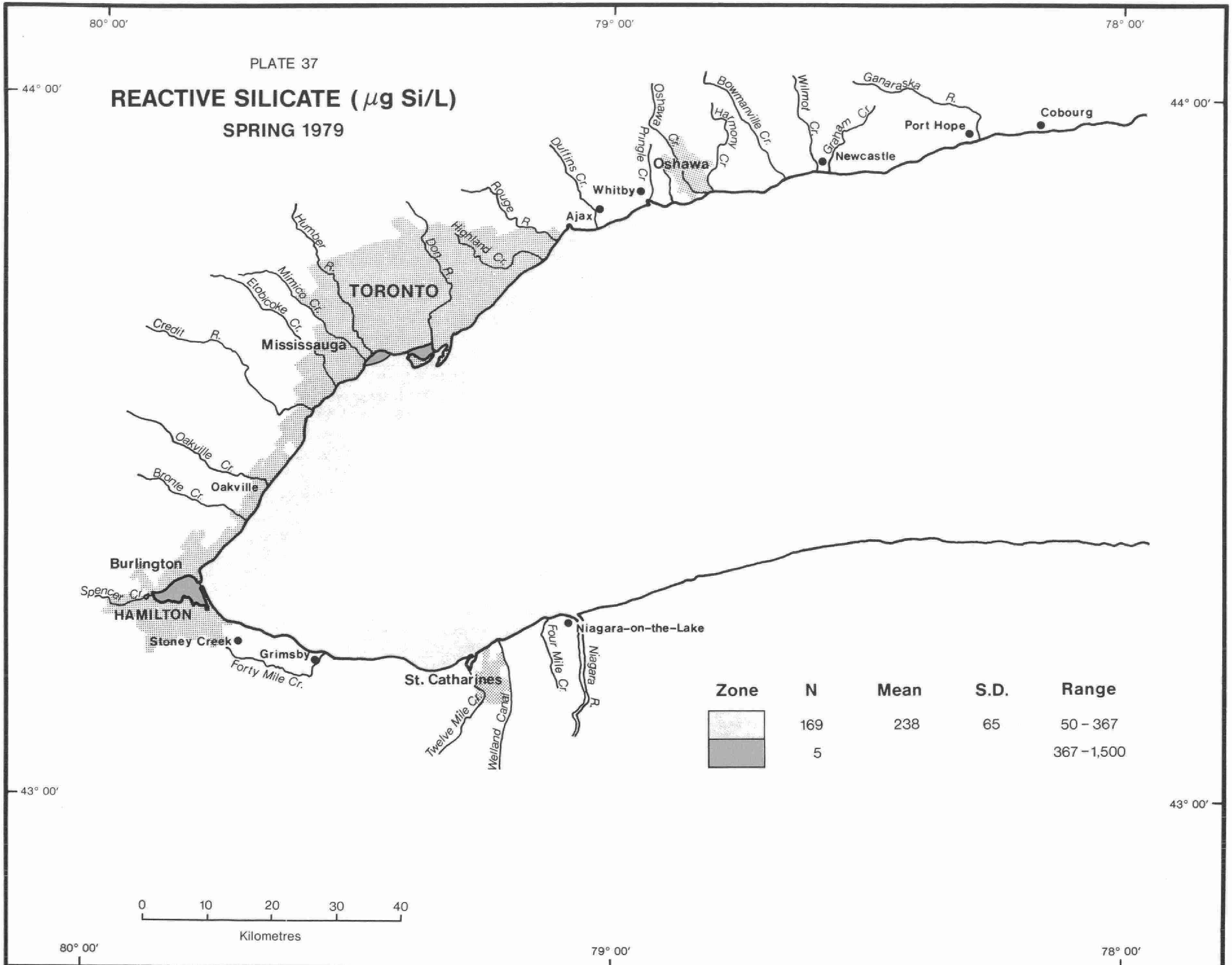


Zone	N	Mean	S.D.	Range
(light stipple)	155	25	33	6 - 35
(dark shading)	19	141	108	39 - 448

PLATE 37

REACTIVE SILICATE (μg Si/L)

SPRING 1979

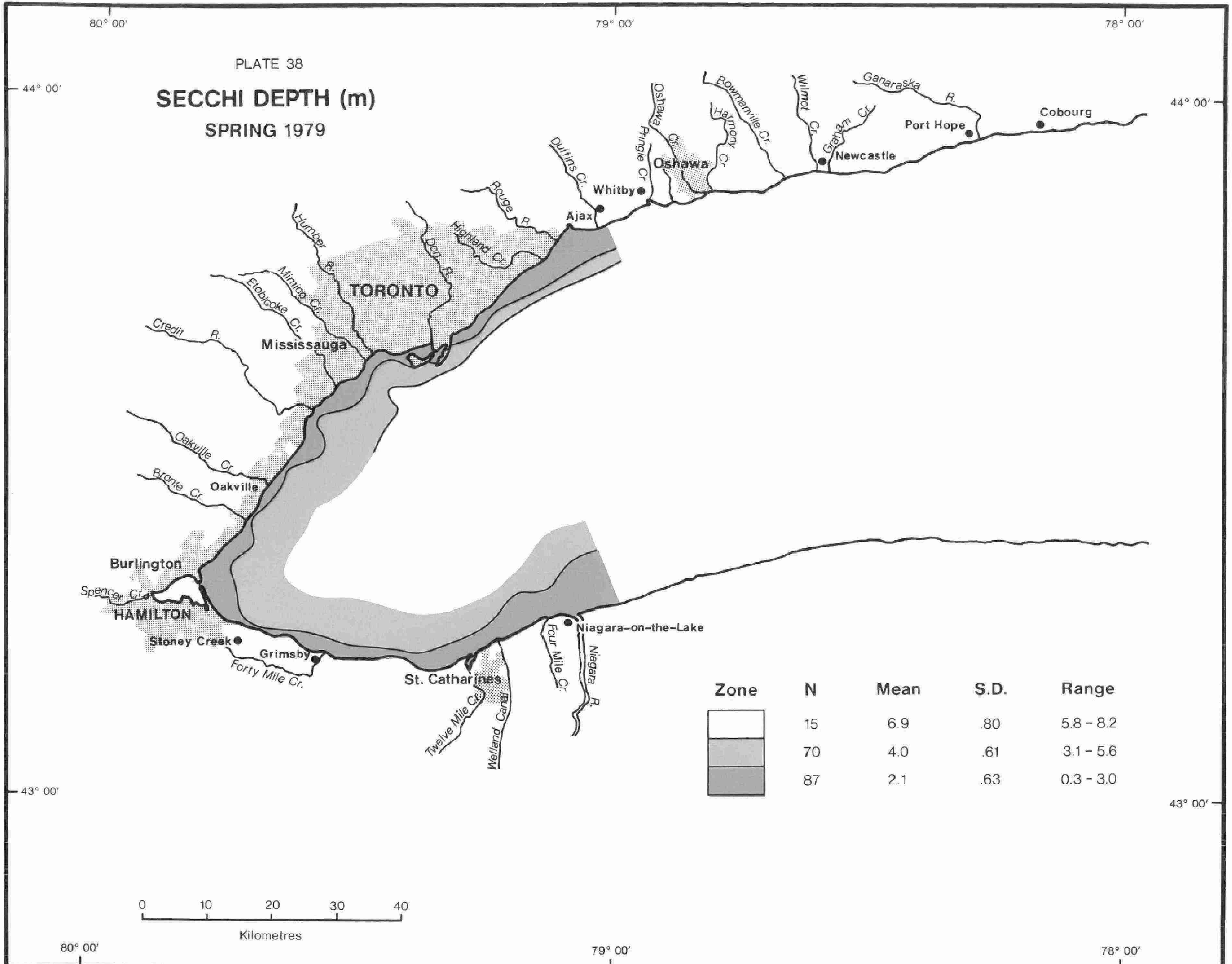


Zone	N	Mean	S.D.	Range
(light)	169	238	65	50 - 367
(dark)	5			367 - 1,500

PLATE 38

SECCHI DEPTH (m)

SPRING 1979

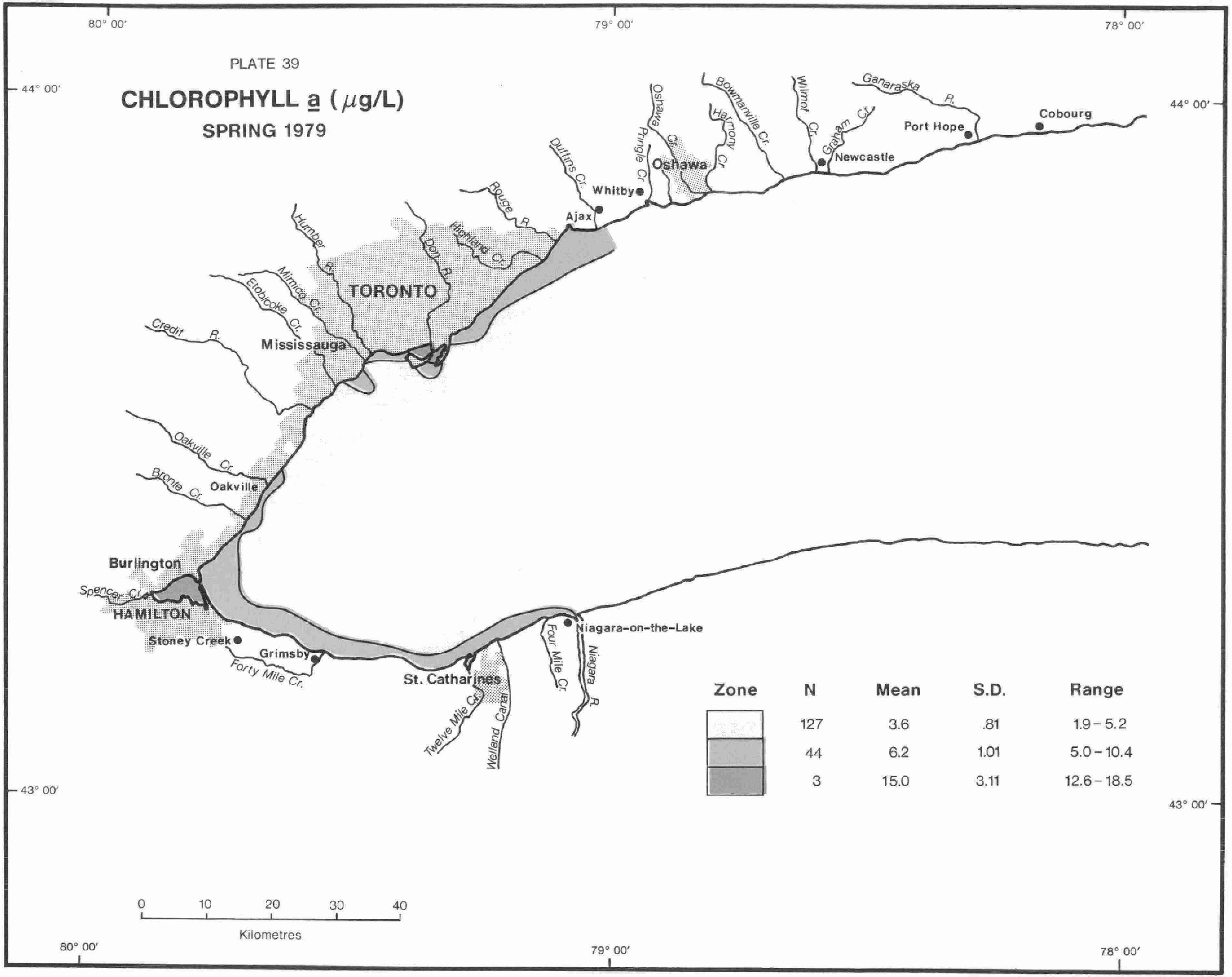


Zone	N	Mean	S.D.	Range
(white)	15	6.9	.80	5.8 - 8.2
(light grey)	70	4.0	.61	3.1 - 5.6
(dark grey)	87	2.1	.63	0.3 - 3.0

PLATE 39

CHLOROPHYLL a (μg/L)

SPRING 1979

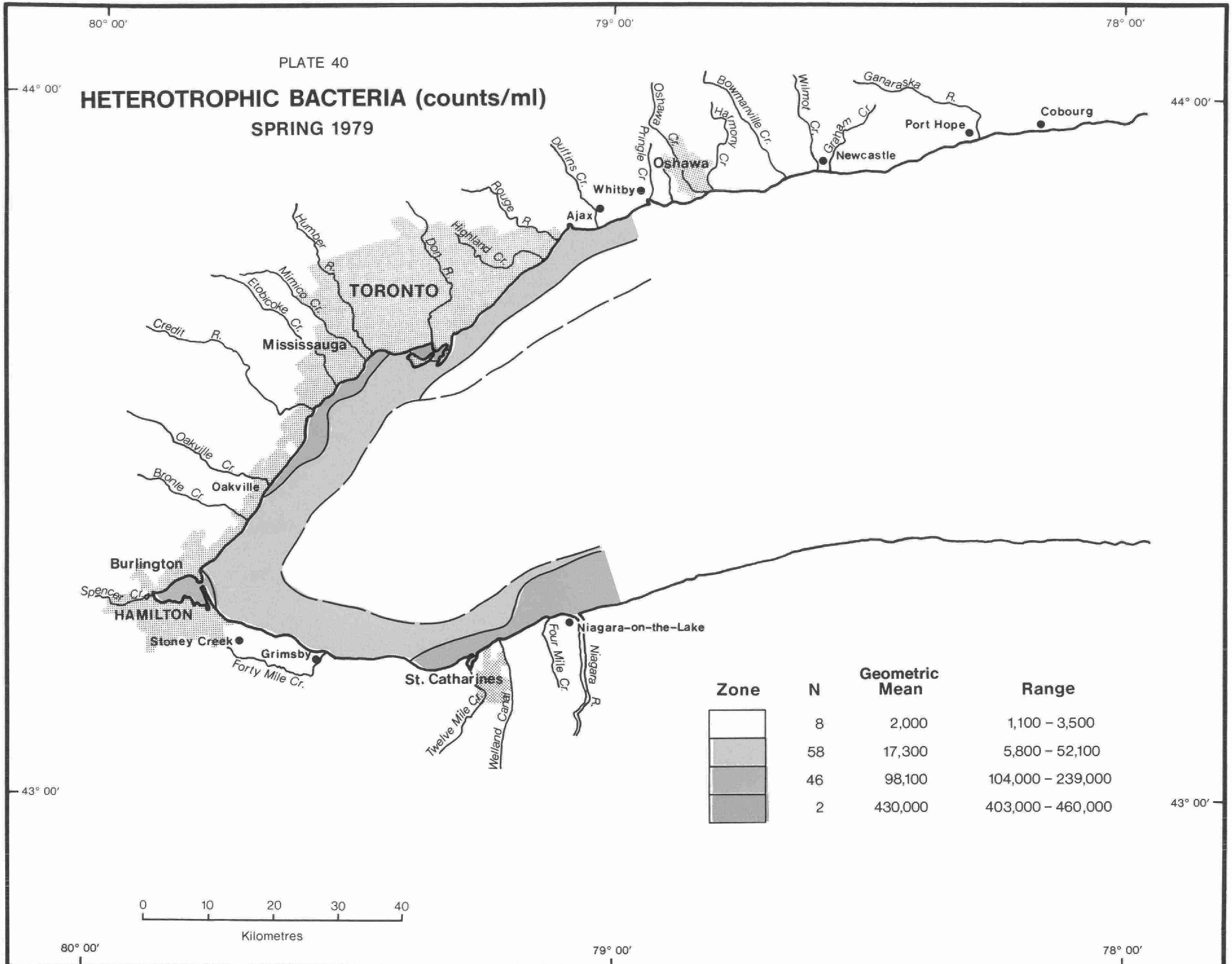


Zone	N	Mean	S.D.	Range
(white)	127	3.6	.81	1.9 - 5.2
(light grey)	44	6.2	1.01	5.0 - 10.4
(dark grey)	3	15.0	3.11	12.6 - 18.5

PLATE 40

HETEROTROPHIC BACTERIA (counts/ml)

SPRING 1979

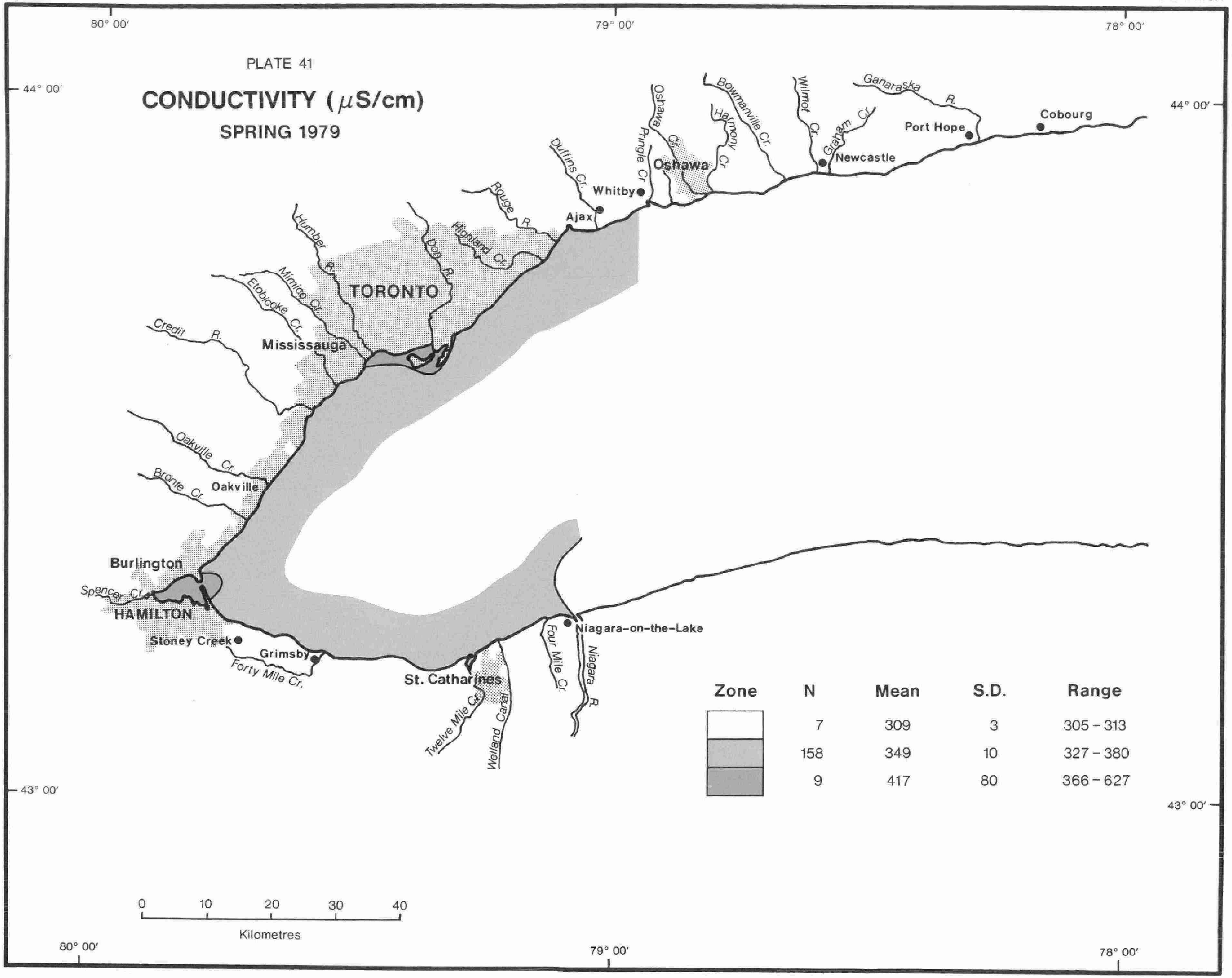


Zone	N	Geometric Mean	Range
(white)	8	2,000	1,100 – 3,500
(light grey)	58	17,300	5,800 – 52,100
(medium grey)	46	98,100	104,000 – 239,000
(dark grey)	2	430,000	403,000 – 460,000

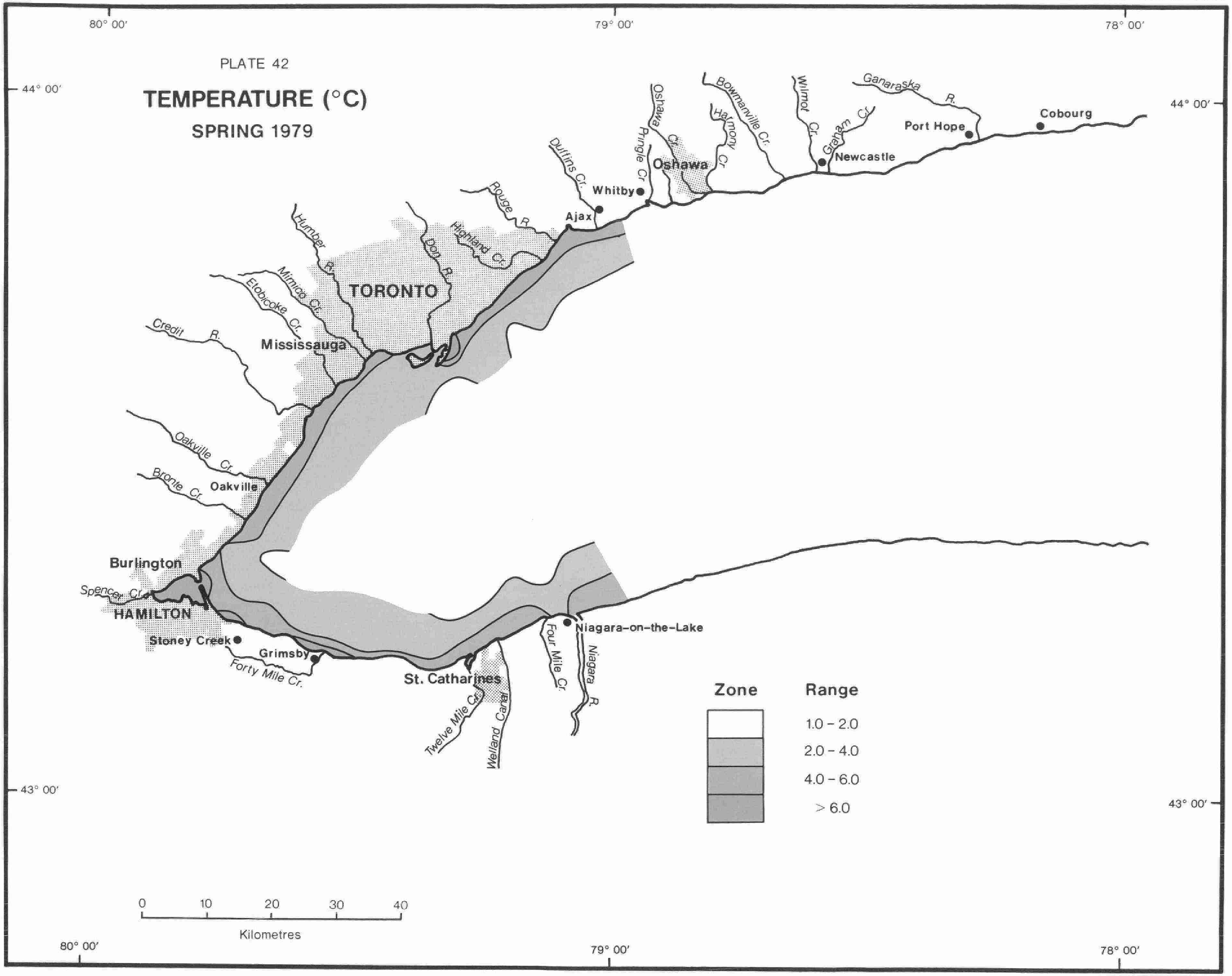
PLATE 41

CONDUCTIVITY (μS/cm)

SPRING 1979



Zone	N	Mean	S.D.	Range
(white)	7	309	3	305 - 313
(light grey)	158	349	10	327 - 380
(dark grey)	9	417	80	366 - 627


80° 00′
79° 00′
78° 00′
44° 00′
43° 00′
PLATE 42
TEMPERATURE (°C)
SPRING 1979
Cobourg
Port Hope
Newcastle
Ganaraska R.
Wilmot Cr.
Graham Cr.
Bowmanville Cr.
Harmony Cr.
Oshawa Cr.
Oshawa
Pringle Cr.
Whitby
Duffins Cr.
Ajax
Rouge R.
Highland Cr.
Don R.
Humber R.
TORONTO
Mimico Cr.
Etobicoke Cr.
Mississauga
Credit R.
Oakville Cr.
Oakville
Bronte Cr.
Burlington
Spencer Cr.
HAMILTON
Stoney Creek
Grimsby
Forty Mile Cr.
St. Catharines
Twelve Mile Cr.
Welland Canal
Four Mile Cr.
Niagara-on-the-Lake
Niagara R.
Zone
Range
1.0 - 2.0
2.0 - 4.0
4.0 - 6.0
> 6.0
0
10
20
30
40
Kilometres